TITLE: SYNTHESIS OF ORGANOMETALLIC COMPLEXES OF MEDICINAL RELEVANCE

Topic number : ***2022_001***

Field : Chemistry, Physical chemistry and Chemical Engineering, Life and Health Science and Technology,

Subfield: Organometallic Chemistry, Medicinal Inorganic Chemistry, Synthesis.

ParisTech School: Chimie ParisTech - PSL
Research team: Laboratory for Inorganic Chemical Biology
http://www.gassergroup.com
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:http://www.gassergroup.com

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Gasser Gilles gilles.gasser@chimieparistech.psl.eu
Advisor 2: Cariou Kevin kevin.cariou@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: This project relates to the preparation and characterization of novel organometallic compounds for medicinal application (antiparasitic and antifungal agents) Over the last years, organometallic complexes have been found to be extremely promising anticancer and antiparasitic drug candidates, with even one such compound (i.e. Ferroquine) reaching phase II clinical trial. In this project, we envisage to undertake a structure-activity study to unveil novel lead compounds against several parasitic diseases such as schistosomiasis or toxoplasma and antifungal infections.
The applicant will therefore have to first synthesize and characterize (NMR, MS, X-ray crystallography, electrochemistry) new organometallic compounds. She/he will then have to assess the stability in biological media (i.e. human plasma) of these compounds as well as perform metabolic studies to understand the fate of the compounds in the presence of different enzymes. The antiparasitic experiments will be undertaken by collaborators in Switzerland, USA and Italy.

Required background of the student: The applicant should have a sound knowledge (theoretical and practical) in both inorganic and organic chemistry (including Schlenk techniques) and be proficient with analytical techniques such as NMR and MS. The applicant must be fluent in English since it is the language spoken in the Gasser group.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Y. Lin, H. Betts, S. Keller, K. Cariou, and G. Gasser, Chem. Soc. Rev., 2021, 50, 10346-10402.

2. R. Rubbiani, T. Weil, N. Tocci, L. Mastrobuoni, S. Jeger, M. Moretto, J. Ng, Y. Lin J. Hess, S. Ferrari, A. Kaech, L. Young, J. Spencer, A. L. Moore, K. Cariou, R. Giorgia, L. Romani, M. Pariano and G. Gasser, RSC Chem. Biol., 2021, 2, 1263-1273.

3. H.D. Betts, Y.C. Ong, N. Anghel, S. Keller, J. Karges, N. Voutsara, J. Müller, E. Manoury, O. Blacque, K. Cariou, A. Hemphill, and G. Gasser, Organometallics, 2022, 41, 2035-2041.

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Illustrations :

ParisTech

TITLE: ELECTROCHEMICAL ACTIVATION OF YNAMIDES

Topic number : ***2022_002***

Field : Chemistry, Physical chemistry and Chemical Engineering, ,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Inorganic Chemical Biology Laboratory
http://www.gassergroup.com/
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:http://www.gassergroup.com/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Cariou Kevin kevin.cariou@chimieparistech.psl.eu
Advisor 2: Gasser Gilles gilles.gasser@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In the last 10 years, ynamides, have emerged as very attracting reagents and building blocks for organic synthesis. Thanks to their highly polarized triple bond, ynamides have become partners of choice for a myriad of reactions, including cyclizations or asymmetric transformations, through a variety of activation modes. Taking into consideration the recent surge of interest for redox strategies in synthetic chemistry, we seek to design original ynamide derivatives that could be redox-activated under mild conditions, such as electrochemistry, to trigger unprecedented reaction pathways.

Required background of the student: The applicant should have strong theoretical and practical background in organic chemistry. Mastery of purification and analysis (NMR, MS, IR, etc.) techniques is mandatory as well as excellent written and oral communication skills and the ability to work as part of a team. The applicant must be fluent in English since it is the language spoken in the Gasser group. Practical knowledge/experience in synthetic electrochemistry and photocatalyis would be an asset.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. N-Metallocenyl Ynamides: Preparation, Oxidative Functionaliza-Tion and Synthesis of an Ansa-Ferrocenylamide. Mahe, C.; Blacque, O.; Gasser, G.; Gandon, V.; Cariou, K. ChemRxiv 2022 (doi: 10.26434/chemrxiv-2022-3fh1t-v2)
2. Base-Mediated Generation of Ketenimines from Ynamides: Annulation with Azaallyl Anions D'Hollander, A. C. A.; Romero, E.; Vijayakumar, K.; Le Houérou, C.; Retailleau, P.; Dodd, R. H.; Iorga, B. I.; Cariou, K.* Adv.Synth. Cat. 2021; 362, 2903–2908
3. Ynamides in Free Radical Reactions Mahe, C.; Cariou, K.*Adv.Synth. Cat. 2020; 362, 4820–4832.
4.
5.

Illustrations :

ParisTech

ESPCI PARIS PSL

TITLE: ACTIVE SOLIDS

Topic number : ***2022_003***

Field : Physics, Optics, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team:
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location: Paris
Lab website:https://www.gulliver.espci.fr

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Dauchot Olivier olivier.dauchot@espci.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Active materials are composed of motorized units, which, interacting together, eventually develop collective dynamics. In the past 20 years, a large amount of work has dealt with the study of active liquids, for which the active units self-propel in a dilute phase and exhibit collective motion. Conversely, although driven solid architectures are common in living matter e.g. in our own tissues, where molecular motors stiffen and contract biopolymer networks, their physics remains poorly explored.

In the past three years we have tailored an artificial system that combines activity and elastic architecture and demonstrated that selective and collective actuation is a hallmark of active solids . These results open a brand-new avenue of research, from further experimental and numerical investigations to theoretical analysis. Examples of open questions are:

- What is the fate of collective actuation in the thermodynamics limit?

- Is there a transition controlled by the noise amplitude and of what type?

- How does the sound propagate in such active solids?

- What is the mechanical response of such materials?
- …?

We will run new experiments, taking advantage of our existing set-up as well as our « walking grains », a system of self-propelled particles, which we have developed and extensively used in the past ten years. We also have good numerical models of these systems, which can be usefull in examining the large-scale physics.

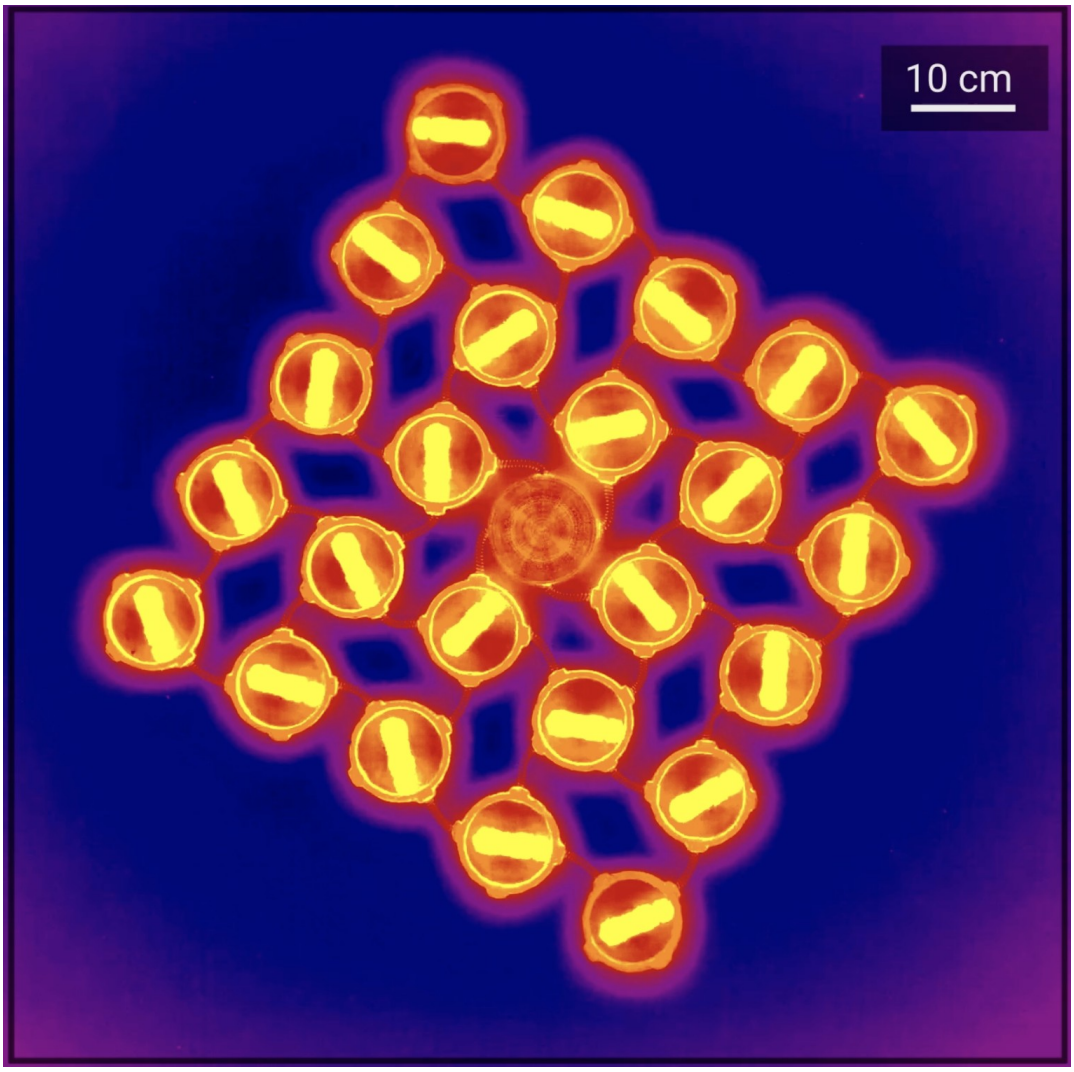
We are looking for a highly motivated student, looking for a challenging exploratory project.

Required background of the student: Physics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. 1. Baconnier, P., Shohat, D., López, C.H. et al. Selective and collective actuation in active solids. Nat. Phys. (2022). https://doi.org/10.1038/s41567-022-01704-x
2. 2. Baconnier, P., Shohat, D., & Dauchot, O. (2022). Tension-controlled switch between collective actuations in active solids. arXiv preprint arXiv:2208.09258.
3. 3. Dauchot, O., & Démery, V. (2019). Dynamics of a self-propelled particle in a harmonic trap. Physical review letters, 122(6), 068002.
4. 4. Bricard, A., Caussin, J. B., Desreumaux, N., Dauchot, O., & Bartolo, D. (2013). Emergence of macroscopic directed motion in populations of motile colloids. Nature, 503(7474), 95-98.
5. 5. Briand, G., Schindler, M., & Dauchot, O. (2018). Spontaneously flowing crystal of self-propelled particles. Physical review letters, 120(20), 208001.

Illustrations :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ParisTech

ESPCI PARIS PSL

TITLE: MORPHO-FUNCTIONAL SWARM ROBOTICS

Topic number : ***2022_004***

Field : Physics, Optics, Information and Communication Science and Technology,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team:
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location: Paris
Lab website:https://www.gulliver.espci.fr

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Dauchot Olivier olivier.dauchot@espci.fr
Advisor 2:
Advisor 3:
Advisor 4:

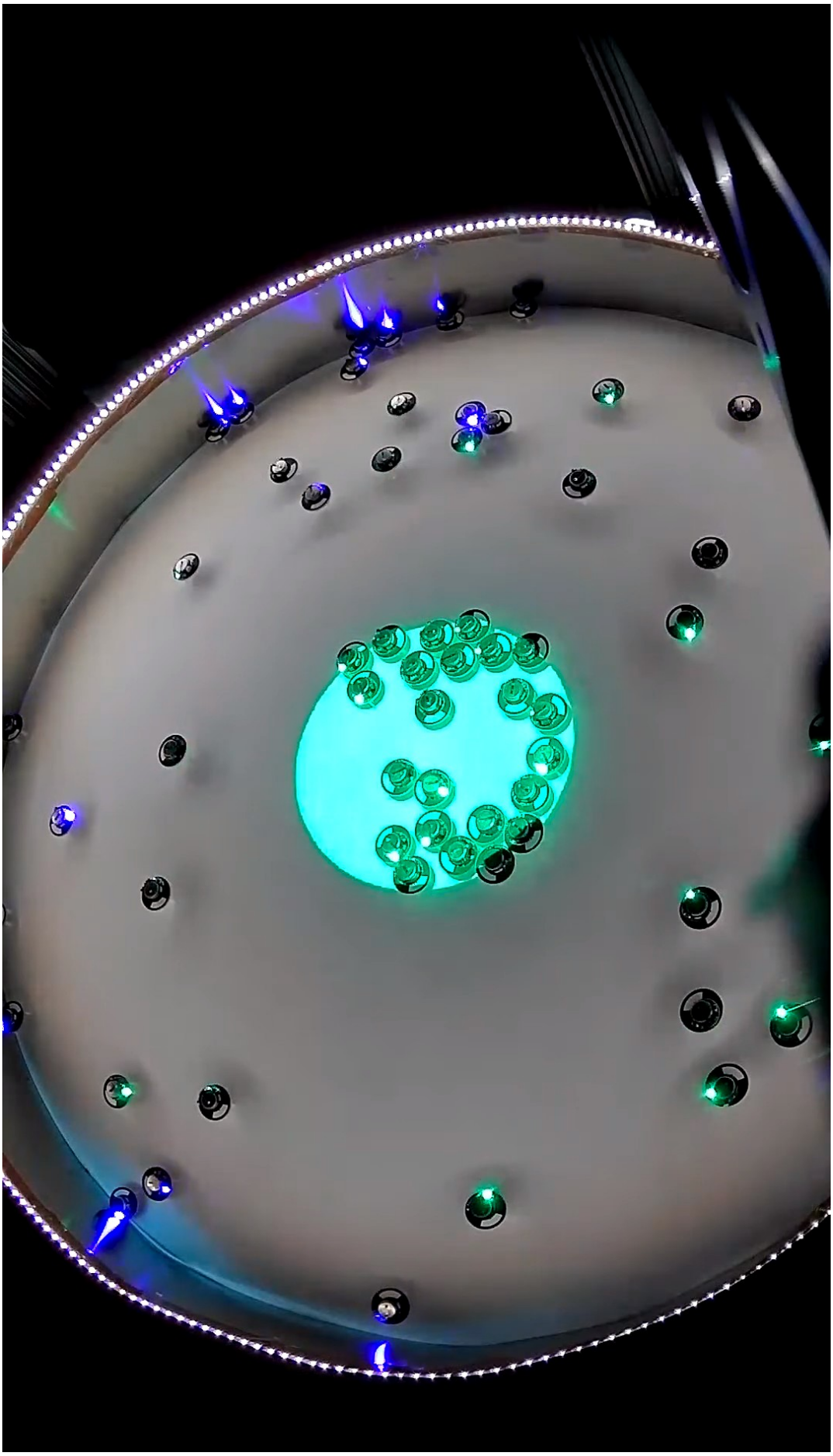
Short description of possible research topics for a PhD: We are interested in swarm robotics, where a large number of robots with limited computation and communication power are considered. Our goal is to propose new design methods, with a particular focus on considering the role of physical interactions among individuals. Embodiment is critical and useful for programming self-organizing collective systems. We thus propose to achieve collective decision making using both morphological and logical computation in swarm robotics.
The PhD research will be the follow up of a 3 year program, during which we achieved the design of a new kind of swarm robotics set-up. The goal of the PhD research plan will be to obtain specific educated collective behaviors: starting from the spontaneous phase obtained from the purely physical interaction of the robots and applying minimal control from embodied capabilities on each robot, we will induce collective behavior, which we will refer to as operational phases. Optimization of such behavior will allow for the realization of complex collective tasks

Required background of the student: Physics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. 1. Zion, M. Y. B., Bredeche, N., & Dauchot, O. (2021). Distributed on-line reinforcement learning in a swarm of sterically interacting robots. arXiv preprint arXiv:2111.06953.
2. 2. Fontbonne, N., Dauchot, O., & Bredeche, N. (2020, July). Distributed on-line learning in swarm robotics with limited communication bandwidth. In 2020 IEEE Congress on Evolutionary Computation (CEC) (pp. 1-8). IEEE.
3. 3. Mirhosseini, Y., Zion, M. Y. B., Dauchot, O., & Bredeche, N. (2022, July). Adaptive phototaxis of a swarm of mobile robots using positive and negative feedback self-alignment. In Proceedings of the Genetic and Evolutionary Computation Conference (pp. 104-112).
4. 4. J-M. Montanier, S. Carrignon, N. Bredeche (2016) Behavioural Specialisation in Embodied Evolutionary Robotics: Why so Difficult? Frontiers in Robotics and AI, Volume 3, number 38.
5.

Illustrations :



ParisTech

TITLE: MODELING THE ELECTRONIC AND OPTICAL PROPERTIES OF VAN DER WAALS HETEROSTRUCTURES

Topic number : ***2022_006***

Field : Chemistry, Physical chemistry and Chemical Engineering, ,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Chemical Theory and Modelling team
https://www.quanthic.fr
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:https://iclehs.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: LABAT FREDERIC frederic.labat@chimieparistech.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The field of two-dimensional (2D) materials has been the subject of numerous studies with various applications targeted in fundamental physics, (opto)electronics, energy and biology . 2D materials refer to thermodynamically stable materials in layers which are just a few atoms thick, which can eventually be stacked together to design heterostructures made of different materials with novel electronic and optical properties. However, the existence of strong chemical bonds between the constituent materials usually lead to chemical disorder at the interface and undesired interfacial electronic states which are difficult to control, and which can significantly alter the properties of those heterostructures, hence limiting the choice of constituent materials to ones with similar chemical composition, lattice structure and/or electronic properties. On the other hand, in the so-called van der Waals (vdW) heterostructures, layers are held together by weak vdW forces without direct chemical bonds, allowing to combine different constituent materials more freely. Without large interfacial strain or lattice disorder at the interface, the intrinsic properties of the constituent materials can thus be retained, permitting to design heterostructures with targeted properties more easily .

The aim of this project is to better understand, from a modeling viewpoint, the geometric, electronic, and optical properties of various vdW heterostructures and in particular how the stacking affects the intrinsic properties of the constituent materials. Methods rooted on Density Functional Theory (DFT), time-dependent DFT and electrostatic embedding will be considered during this project.

Required background of the student: Physical Chemistry, Chemical Physics and, if possible, theoretical chemistry and previous programming experience

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Z. Lin et al. APL Materials 6, 080701 (2018).

2. P. Wang et al. Matter 4, 552 (2021).

3. L. Wilbraham et al. J. Chem. Theory Comput. 12, 3316 (2016).

4. D. Luise et al. J. Comput. Chem. 42, 1212 (2021)

5.

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: MULTISCALE STRESS/STRAIN ANALYSIS OF POLYCRYSTALLINE SILICON FOR PHOTOVOLTAIC APPLICATIONS

Topic number : ***2022_007***

Field : Material science, Mechanics and Fluids, Energy, Processes,

Subfield:

ParisTech School: Arts et Métiers
Research team: MMS (Mechanics, Materials and Surfaces) https://www.msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: BARRALLIER Laurent laurent.barrallier@ensam.eu
Advisor 2:
Advisor 3:
Advisor 4:

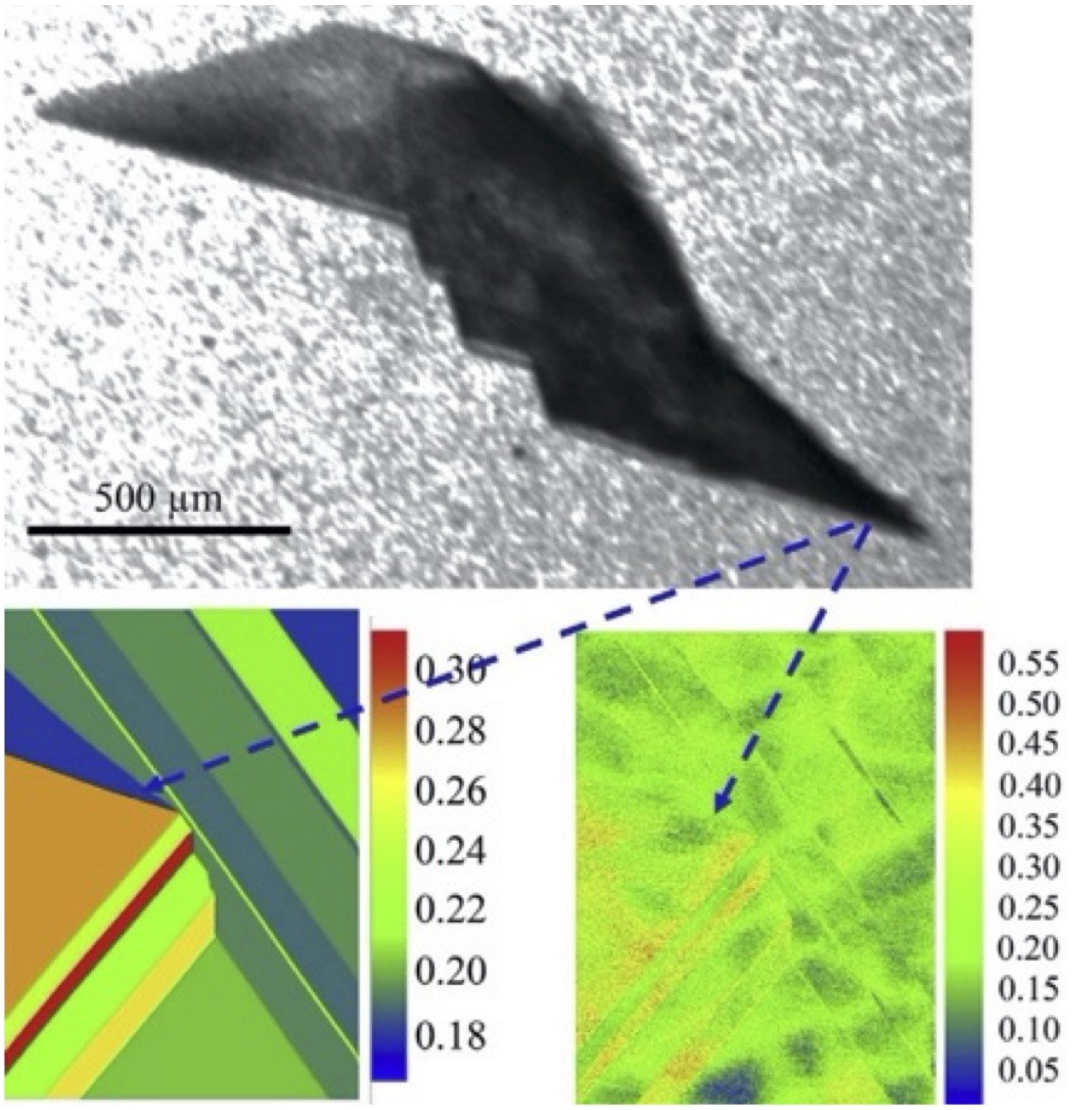
Short description of possible research topics for a PhD:
Polycrystalline silicon (PS) is a raw material used by the solar photovoltaic (PV) and electronics industry. The reduction of the cost of PV cells production is largely possible by using PS. Nevertheless, the limitation of PS use is directly linked to the microstructure of the material i.e. i) the active defects such as grain boundaries, dislocation arrangements, … ii) but also the mechanical fields induced by these defects. The efficiency of PV cells is depending on the mastering of the defect generation, their repartition and the induced strain/stress fields during the fabrication of PS.
The aim of this project is to characterize the induced residual stress fields of PS in relation with their microstructure. Experimental methods used to determine residual stresses fields will be based on multiscale diffraction in-lab technics such as High-Resolution Electron Backscatter Diffraction (HR-EBSD), X-ray diffraction (XRD) of synchrotron facility. To understand the origin of residual stress fields in PS cells, the temperature HR-EBSD and XRD measurements will be coupled with polycrystalline thermo-elasto-plasticity simulation using finite element method (FEM).

Required background of the student: Materials Science and/or Mechanical Engineering

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Becker, E. Pihan, F. Guittonneau, L. Barrallier, G. Regula, H. Ouaddah, G. Reinhart, and N. Mangelinck-Noël. Investigation of subgrains in directionally solidified cast mono-seeded silicon and their interactions with twin boundaries. Solar Energy Materials & Solar Cells, 218(110817):1-10, décember 2020.
2. N. Mangelinck-Noel, H. Ouaddah, M. Becker, T. Riberri-Beridot, M. Tsoutsouva, V. Stamelou, G. Regula, G. Reinhart, I. Péricaud, F. Guittonneau, L. Barrallier, J.-P. Valade, A. Rack, E. Boller, and J. Baruchel. X-ray based in situ investigation of silicon growth mechanism dynamics-application to grain and defect formation. Crystals, 10(7):1-25, july 2020.
3. T. Riberi-Béridot, M.G. Tsoutsouva, G. Regula, G. Reinhart, F. Guittonneau, L. Barrallier, and N. Mangelinck-Noël. Strain building and correlation with grain nucleation during silicon growth. Acta Materiala, 177:141-150, 09 2019.
4. M.G Tsoutsouva, T. Riberi-Béridot, G. Regula, G. Reinhart, J. Baruchel, F. Guittonneau, L. Barrallier, and N. Mangelinck-Noël. In situ investigation of the structural defect generation and evolution during the directional solidification of 110 seeded growth si. Acta Materiala, 115:210-223, August 2016.
5. T. Riberri-Beridot, N. Mangelinck-Noel, A. Tandjouai, G. Reinhart, B. Billia, B. Lafford, J. Baruchel, and L. Barrallier. On the impact of twinning on the formation of the grain structure of multi-crystalline silicon for photovoltaic applications during directional solidification. Journal of Crystal Growth, (418):38-44, 2015.

Illustrations :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TITLE: SYNTHESIS AND FORMULATION OF BIODEGRADABLE POLYMERS FROM RENEWABLE RESOURCES

Topic number : ***2022_008***

Field : Chemistry, Physical chemistry and Chemical Engineering, Life and Health Science and Technology,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Organometallic Chemistry and Polymerization Catalysis http://www.ircp.cnrs.fr/la-recherche/equipe-cocp/
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.chimieparistech.psl.eu/en/research-at-chimie-paristech/laboratories/ircp-en/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: BOUCHEMAL Kawthar
kawthar.bouchemal@chimieparistech.psl.eu
Advisor 2: THOMAS Christophe
christophe.thomas@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Ring-opening polymerization (ROP) of N-carboxyanhydrides (NCA) can produce homopolymers and block-copolymers with well-controlled structures where repeat units are natural amino acids. Similar to proteins, these synthetic polypeptides possess well-defined secondary structures (alpha-helix and beta-sheets), whereas synthetic polymers generally present a disordered coil structure. Therefore, these biomimetic polymers produce sophisticated superstructures with new material properties. We will aim to develop an efficient route from readily available reactants to synthesize new polypeptide analogs with a conserved ability to form well-defined secondary structures.
In this regard, bimetallic catalysts are ideal candidates for this purpose since the polar organometallic moiety will act as a strong nucleophile with concomitant electrophilic assistance created through the coordination of carbonyl oxygen of urea by the lithium cation. Therefore, we want to use these bimetallic systems to synthesize aliphatic polyureas

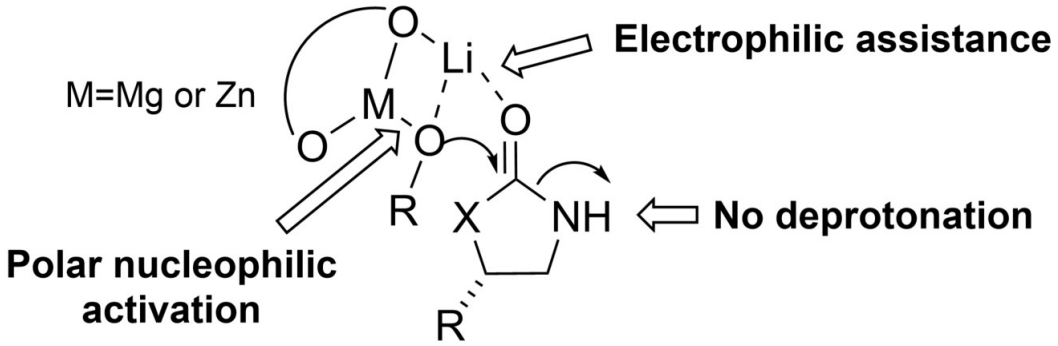
and polyurethanes via one-pot catalytic transformation where cyclic urethanes or ureas are synthesized from, respectively, epoxides or aziridines and subsequently polymerized by ROP.
In the second set of experiments, the physicochemical properties of the polypeptide analogs will be characterized, and their ability to self-assemble as supramolecular nanostructures will be investigated.4,5 The morphology, surface charge, and nanomechanical properties will be assessed using conventional physicochemical and physical characterization methods. Once prepared and characterized, the behaviors of the polypeptide analogs nanostructures regarding biological systems will be investigated.

Required background of the student: Polymer Chemistry & Formulation

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Chem. Commun., 2014, 50, 13773.
2. Nature Comm., 2011, 2, 586.
3. Chem. Soc. Rev., 2013, 42, 9392.
4. J. Control. Release, 2022, 342, 93.
5. Colloids Surf. B, 2021, 205, 111916.

Illustrations :



TITLE: SMART MATERIAL DESIGN FOR VECTORIZATION OF BIOCOMPATIBLE AND BIODEGRADABLE POLYMER-COATED NANOPARTICLES

Topic number : ***2022_009***

Field : Chemistry, Physical chemistry and Chemical Engineering, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Organometallic Chemistry and Polymerization Catalysis https://www.ircp.cnrs.fr/la-recherche/equipe-cocp/
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.chimieparistech.psl.eu/en/research-at-chimie-paristech/laboratories/ircp-en/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: GAUVIN Régis regis.gauvin@chimieparistech.psl.eu
Advisor 2: THOMAS Christophe christophe.thomas@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The design of efficient vectorizing agents is the cornerstone of modern pharmaceutical agents. In this view, the tailoring of specific (molecular) objects by covalent bonding with polymer chains is of great interest to confer them significant compatibility with physiological environments.

In this view, biocompatible and biodegradable polymers are ideal candidates as components within such advanced formulations. These can be most efficiently prepared using ring opening polymerization (ROP) of lactones or lactides into polyesters or polylactic acid mediated by organometallic initiators. On the top of that, immobilization of organometallics on inorganic surfaces via surface was demonstrated to boost stereoselectivity of these considered polymerization processes. In this project, we propose to combine surface organometallic chemistry and ROP of polar monomers to design specific nanoobjects by “growing from” or “growing on” approaches, where chain growth is mediated by specifically designed supported organometallic entities. The ultimate goal

will be the development of biopolymer-coated nanoparticles for future implementation into drug delivery systems.

Required background of the student: Polymer Chemistry, Material science

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. N. Soliman, L. K. McKenzie, J. Karges, E. Bertrand,M. Tharaud, M. Jakubaszek, V. Guérineau,B. Goud, M. Hollenstein, G. Gasser, C. M. Thomas, Chem. Sci., 2020, 11, 2657-2663.

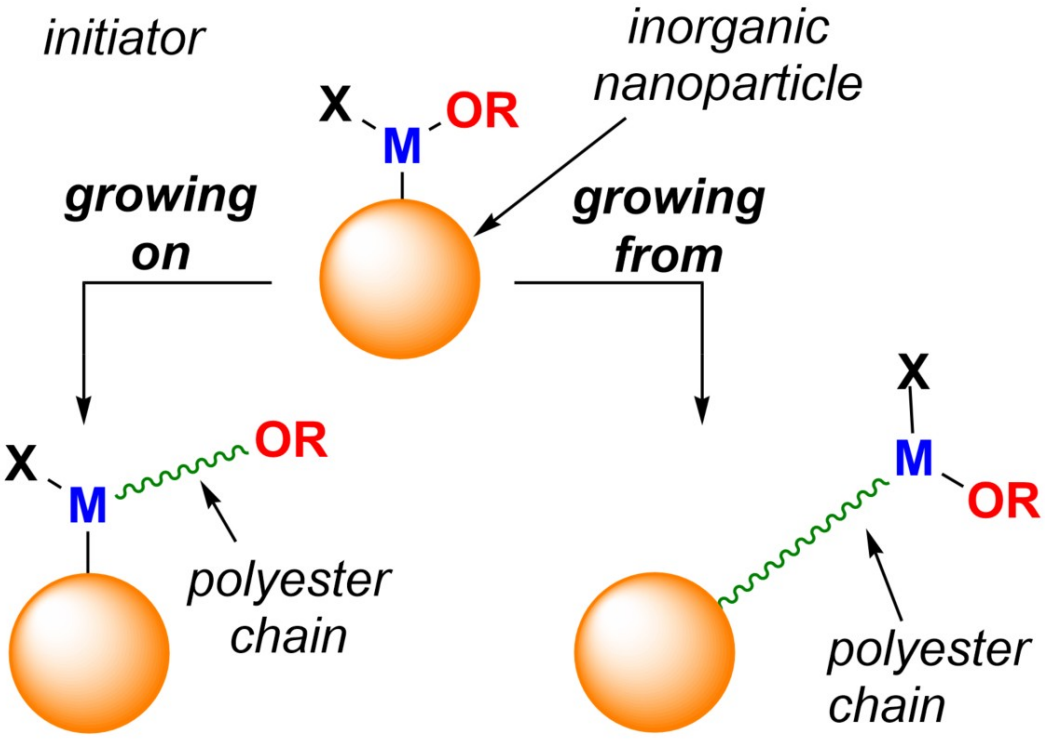
2. P. Marin, M. J.-L. Tschan, F. Isnard, C. Robert, P. Haquette, X. Trivelli, L.-M. Chamoreau, V. Guérineau, I. del Rosal, L. Maron, V. Venditto, C. M. Thomas, Angew. Chem. Int. Ed. 2019, 58, 12585-12589.

3. M. J.-L. Tschan, R. M. Gauvin, C. M. Thomas, Chem. Soc. Rev., 2021, 50, 13587-13608.

4. N. Ajellal, G. Durieux, L. Delevoye, G. Tricot, C. Dujardin, C. M. Thomas, R. M. Gauvin, Chem. Commun. 2010, 46, 1032-1034.

5.

Illustrations :



ParisTech

TITLE: PRODUCTION OF SUSTAINABLE POLYMERS BY ONE-POT CATALYSIS

Topic number : ***2022_010***

Field : Chemistry, Physical chemistry and Chemical Engineering, ,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Organometallic Chemistry and Polymerization Catalysis https://www.ircp.cnrs.fr/la-recherche/equipe-cocp/
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.chimieparistech.psl.eu/en/research-at-chimie-paristech/laboratories/ircp-en/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: THOMAS Christophe
christophe.thomas@chimieparistech.psl.eu
Advisor 2: GAUVIN Régis regis.gauvin@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

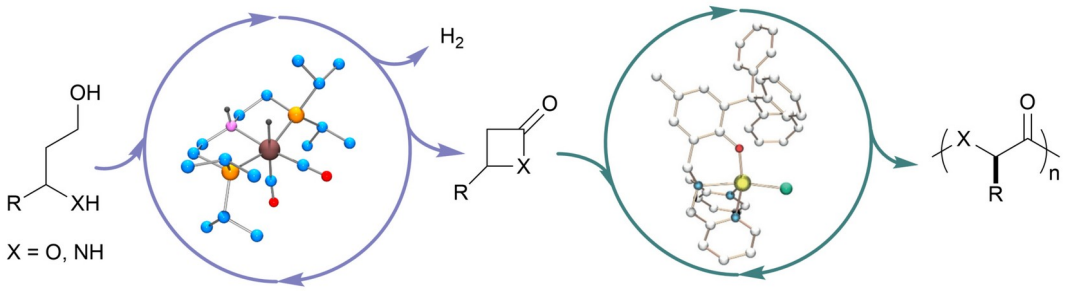
Short description of possible research topics for a PhD: The development of new methods to transform biomass into resources suitable for polymer production remains a crucial obstacle on the way to a more sustainable chemical economy. In this regard, the creation of renewable polymers through one-pot catalysis represents an important tool to support more sustainable plastics production. In this project, hydrogen borrowing, a clean atom-economical technology, will be harnessed in a first step to synthesize lactones or lactames monomers from biosourced raw materials. These will then be polymerized through stereoselective ring opening polymerization, providing novel polyesters or polyamides. An intense emphasis will be placed on the design of new organometallic catalysts based on Earth-abundant metals, as well as on establishing the physicochemical properties of the polymers.

Required background of the student: Polymer chemistry, catalysis

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Fouilloux, H.; Rager, M.-N.; Ríos, P.; Conejero, S.; Thomas, C. M. Angew. Chem., Int. Ed. 2022, 61, e202113443.
2. Upitak, K.; Thomas, C. M. Acc. Chem. Res. 2022, 55, 2168.
3. a) Robert, C.; De Montigny, F.; Thomas, C. M. Nat. Commun. 2011, 2, 586. b) Fouilloux, H.; Qiang, W.; Robert, C.; Placet V.; Thomas, C. M. Angew. Chem., Int. Ed. 2021, 60, 19374.
4. Nguyen, D. H.; Trivelli, X.; Capet, F.; Paul, J.-F.; Dumeignil, F.; Gauvin R. M. ACS Catal., 2017, 7, 2022.
5. Marin, P.; Tschan, M. J.-L.; Isnard, F.; Robert, C.; Haquette, P.; Trivelli, X.; Chamoreau, L.-M.; Guérineau, V.; del Rosal, I.; Maron, L.; Venditto, V.; Thomas C. M. Angew. Chem. Int. Ed. 2019, 58, 12585.

Illustrations :



ParisTech

Arts et Métiers Sciences et Technologies

TITLE: DEVELOPMENT OF A HIGH ORDER MODEL FOR FLUID-STRUCTURE INTERACTION : APPLICATION TO SOFT SOLIDS

Topic number : ***2022_011***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LIFSE - Laboratoire Ingénierie des Fluides Systèmes Energétiques
Lab location: Paris
Lab website:https://lifse.artsetmetiers.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Specklin Mathieu mathieu.specklin@ensam.eu
Advisor 2: Khelladi Sofiane sofiane.khelladi@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Interactions between fluids and flexible structures occur both in natural phenomena and in industrial processes. One can cite for instance : biomedical applications (blood cells, aortic valve leaflets), energy conversion devices (membranes of volumetric compressors), energy harveting (small bio-inspired wind turbine), and so on. The present project will focus more particularly on highly deformable solids following an hyperelastic behavior, the so-called soft solids. Predicting the physics of these interactions through computational models will both ensure a greater understanding of the phenomena involved and, enable the optimisation of the industrial processes where those interactions occur. This research project aims at developing an innovative, accurate and practical numerical model, for the prediction of fluid structure interactions involving flexible structures. The main novelty of the present research project is the combination of the following numerical advance solutions: (i) high order numerical schemes, (ii) finite Volume Formulation on unstructured grids and (iii) full Eulerian formulation for fluid-structure interaction for hyperelastic solids. Medium and long terms applications of this numerical tool encompass expertise studies of this type of fluid-structure interactions.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. S. S. Jain, K. Kamrin, A. Mani, A conservative and non-dissipative Eulerian formulation for the simulation of soft solids in fluids, Journal of Computational Physics, 399 (2019), https://doi.org/10.1016/j.jcp.2019.108922
2. K. Kamrin, C. H. Rycroft, J-C. Nave, Reference map technique for finite-strain elasticity and fluid-solid interaction, Journal of the Mechanics and Physics of Solids, 60 (2012), 1952–1969, http://dx.doi.org/10.1016/j.jmps.2012.06.003
3. Specklin, M., Dubois, P., Albadawi, A., Delaure, Y., A full immersed boundary solution coupled to a Lattice-Boltzmann solver for multiple fluid-structure interactions in turbulent rotating flows, Journal of Fluids and Structures, 90 (2019), 205-229, https://doi.org/10.1016/j.jfluidstructs.2019.06.014
4.
5.

Illustrations :

TITLE: OXIDE-BASED CRYSTALS DOPED BY PR3+, DY3+ OR TB3+ FOR SOLID-STATE VISIBLE LASER : CRYSTAL GROWTH AND OPTICAL SPECTROSCOPIC PROPERTIES

Topic number : ***2022_012***

Field : Chemistry, Physical chemistry and Chemical Engineering, Physics, Optics,

Subfield: Solid-state Chemistry

ParisTech School: Chimie ParisTech - PSL
Research team: MPOE Team (Material for Photonics and OptoElectronic https://www.ircp.cnrs.fr/la-recherche/programmes-scientifiques/#pll_switcher
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.chimieparistech.psl.eu/recherche/les-laboratoires/ircp/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Gerard AKA gerard.aka@chimieparistech.psl.eu
Advisor 2: Pascal LOISEAU pascal.loiseau@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The target of this PhD research Topic is finding suitable oxide host materials for highly efficient continuous wave (cw) asers with direct emission in the visible spectral range at watt-level output power. These lasers will be based on the active ions , Pr3+, Tb3+ and Dy3+, which all provide various emission lines in the visible. Suitable oxides have to provide highly coordinated sites to warrant a low crystal field strength. Moreover, high band-gap energies and low phonon energies are beneficial to avoid energy transition and non-radiative decay processes
During the project, various samples of these Oxide based crystal hosts doped with the rare earth ions Pr3+, Tb3+, and Dy3+ will be grown. These samples will be characterized regarding their structural, optical, thermal and spectroscopic properties with respect the requirements for visible lasing
According to the results of these investigations crystals suitable for laser experiments will be grown and prepared and laser experiments will be

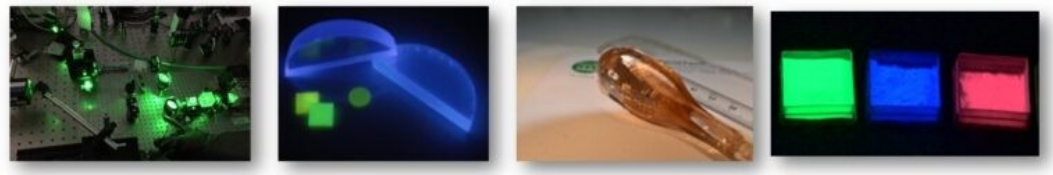
performed under 2w-OPSL and diode pumping. The different techniques which will be involved in this research are the following:
- Solid state chemistry reactions
- X-Ray diffraction
- Thermal analysis (DTA, TGA)
- Czochralski growth techniques
- Thermo mechanical measurement (thermal diffusivity, thermal conductivity etc..)
- Rare earth optical spectroscopy (absorption, emission, lifetime, diagram energy levels)
- Laser test with resonating cavity design

Required background of the student: solid-state chemistry and opical spectroscopy background

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. H. Chen, P. Loiseau, G. Aka, B. Baptiste, P. Veber, Crystal Growth and Characterization of Terbium-Based Borate Crystals of Sr3Tb(BO3)3, Li6Tb(BO3)3, and TbCa4O(BO3)3: Color Centers, Spectroscopic Properties, and Optical Gain
(2020) Crystal Growth and Design, 20 (3), pp. 1905-1919. DOI: 10.1021/acs.cgd.9b01597
2. S. Sattayaporn, P. Loiseau, G. Aka, S. Klimin, K. Boldyrev,B. Mavrin, Fine spectroscopy and Judd-Ofelt analysis of Pr3+ doped Sr0.7La0.3Mg0.3Al11.7O19 (Pr:ASL) (2020) Journal of Luminescence, 219, art. no. 116895, DOI: 10.1016/j.jlumin.2019.116895
3. H. Chen, P. Loiseau, G. Aka, Optical properties of Dy3+-doped CaYAlO4 crystal (2018) Journal of Luminescence, 199, pp. 509-515. DOI: 10.1016/j.jlumin.2018.03.077
4. S. Sattayaporn, P. Loiseau, G. Aka, D. T. Marzahl, C. Kränkel, Crystal growth, spectroscopy and laser performances of Pr3+:Sr0.7La0.3Mg0.3Al11.7O19 (Pr:ASL) (2018) Optics Express, 26 (2), pp. 1278-1289. DOI: 10.1364/OE.26.001278
5.

Illustrations :




a)
b)

ParisTech

Arts et Métiers

TITLE: GEOMETRY PROCESSING FOR REDUCING CYBERSICKNESS IN VR

Topic number : ***2022_013***

Field : Information and Communication Science and Technology, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: XR team
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Chalon-sur-Saône
Lab website:http://lispen.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Lou Ruding ruding.lou@ensam.eu
Advisor 2: Mérienne Frédéric frederic.merienne@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Virtual reality (VR) technologies became more and more widespread for a couple of years as they got more and more mature. The accessibility to VR highly increased thanks to recent low-cost commercial VR head mounted display (HMD) systems and easy-to-use development toolkits. These technologies found strong applications both in professional activities such as virtual product engineering and in personal activities such as video games.
One important and well-studied human perception issue is related to cybersickness. According to the well-known sensory conflict theory, cybersickness is provoked during a VR experience when humans perceive incoherently movements by different physiological sensors on the body. Users can feel visually induced self-motion but they do not feel any movement according to their vestibular system. This incoherent movement perception provokes cybersickness to the users.
To tackle this issue, this PhD thesis will investigate a novel approach for reducing visually induced self-motion by processing geometrically the virtual scene during navigation in VR. In compare with the previous work in the literature, this novel approach does not require neither extra device nor physiological stimulus. In addition this approach will not reduce nor immersive degree nor the freedom of navigation for users, which is not always the case for the related work in the literature. The

main scientific objective is to devise, implement and experiment the optimal geometry processing method and parameters to reduce the cybersickness. Some pilot studies have been published in scientific conferences to show the efficiency of geometric deformation and simplification on the cybersickness
issue .

Y. Wang, J.-R. Chardonnet, and F. Merienne, Design of a semiautomatic travel technique in VR environments, In IEEE VR, pp. 1223–1224, 2019.
R. Lou, Geometry deformation for reducing cybersickness in VR. J. IG-RV, pp.229-234, France 2019.
R. Lou, R. H. Y. So, and D. Bechmann, Geometric deformation for reducing optic flow and cybersickness dose value in VR, In Eurographics 2022.
R. Lou, F. Merienne, R. H. Y. So, T. T. Chan and D. Bechmann, "Geometric simplification for reducing optic flow in VR," IEEE ISMAR 2022

Required background of the student: Computer science, computer graphics, virtual reality

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. R. Lou, Geometry deformation for reducing cybersickness in VR. J. IG-RV, pp.229-234, France 2019
2. R. Lou, Geometry deformation for reducing cybersickness in VR. J. IG-RV, pp.229-234, France 2019
3. R. Lou, F. Merienne, R. H. Y. So, T. T. Chan and D. Bechmann, "Geometric simplification for reducing optic flow in VR," IEEE ISMAR 2022
4. Y. Wang, J.-R. Chardonnet, and F. Merienne, Design of a semiautomatic travel technique in VR environments, In IEEE VR, pp. 1223–1224, 2019
5.

Illustrations :

Geometric simplification for reducing optic flow in VR

Ruding Lou*
LISPEN, Arts et Métiers Institute of Technology
Frédéric Mérienne †
LISPEN, Arts et Métiers Institute of Technology
Richard H. Y. So‡
Hong Kong University of Science and Technology
Tsz-Tai Chan§
Hong Kong University of Science and Technology
Dominique Bechmann¶
ICUBE, CNRS
University of Strasbourg

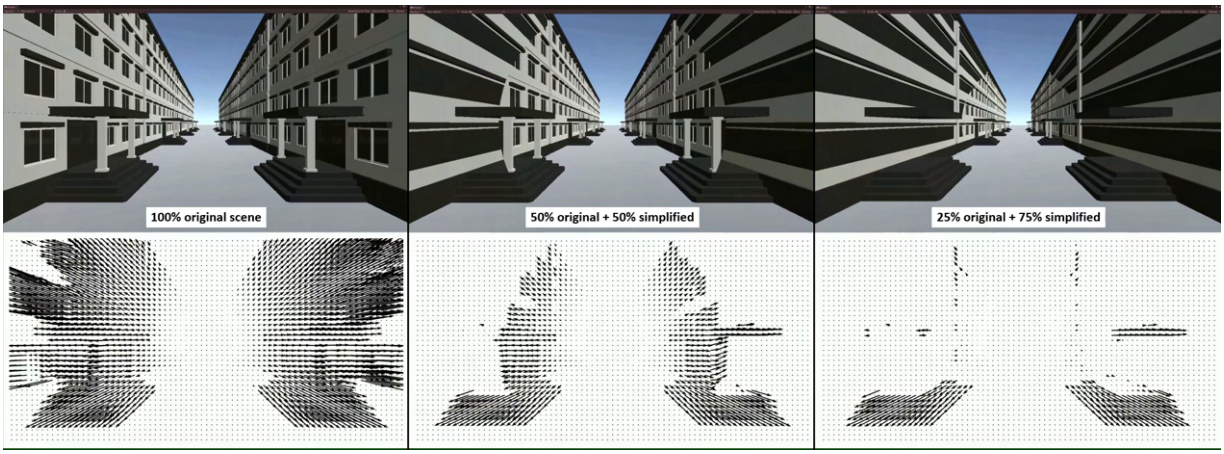


Figure 1: Simplification of the scene (top) for reducing the optic flow in peripheral FOV (bottom).

Abstract

Today virtual reality (VR) technologies became more and more widespread and found strong applications in various domains. However the fear to experience motion sickness is still an important barrier for new VR users. Instead of moving physically, VR users experience virtual locomotion but their vestibular systems do not sense the self-motion that are visually induced by immersive displays. The mismatch in visual and vestibular senses causes sickness. Previous solutions actively reduce user's field-of-view, introduce intruder in the view or alter their navigation. In this paper we propose a passive approach that partially simplify the virtual environment according to user navigation. One manual simplification approach has been proposed and prototyped to simplify the scene seen in the peripheral field of view. The optic flow is analyzed on the rendered images seen by users. The result shows that the simplification reduces the perceived optic flow which is the main cause of the visually induced motion sickness (VIMS). This pilot study confirm the potential efficiency of reducing cybersickness through geometric simplification.

Index Terms: Computing methodologies—Computer graphics—Graphics systems and interfaces—Virtual reality; Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality;

*e-mail: ruding.lou@ensam.eu
†e-mail: frederic.merienne@ensam.eu
‡e-mail: rhyso@ust.hk
§e-mail: ttchanac@connect.ust.hk
¶e-mail: bechmann@unistra.fr

1 Introduction

Virtual reality (VR) applications are no longer confined to gaming. Cheaper and better VR hardware has encouraged more and more applications in workplaces. On one hand the low cost personal computers have high graphic computing capacity and low cost VR headsets have high performance in rendering and tracking [3]. On the other hand various game engines such as Unity3D, Unreal Engine, etc. allow public unprofessional developers to prototype interesting 3D applications for various domains [2]. Therefore VR technologies have been largely applied in various domains such as engineering, cultural heritage, training, medical services and also entertainment.

Under this context many novice VR users have not yet got used to navigation and perception in virtual environment and they can feel discomfort during their virtual experience due to visually induced motion sickness (VIMS). According to the sensory conflict theory, VIMS is provoked during a VR experience when humans perceive incoherently self-motion through vision and vestibular senses. Instead of moving physically, VR users send commands using devices (e.g., gamepad) to move in virtual worlds. Users can feel visually induced self-motion but they do not feel any movement according to their vestibular systems. This incoherent movement perception can provoke cybersickness among susceptible users which is half of the world population [18].

Two objective measures have been shown to influence VIMS: the optic flow generated from visualized images [11] and the cybersickness dose value (CSDV) [17] generated by navigation. The optic flow is motion of light seen in human eyes when human watch illuminated objects moving. It is represented by a vector field in which the light pattern velocity at each point of the field of view (FOV) is quantified. The VR immersion will let users to absorb completely the generated optic flow. The CSDV is related to the velocity and exposure time during navigation as well as the com-

plexity of the VR scene. Our past studies have shown that both the changes of navigation velocity and scene complexity can affect VIMS significantly [19]. This paper focuses on the simplification of VR scenes to reduce VIMS.

2 Related work

Various VIMS counter-measures in VR can be found in the literature to reduce VIMS through managing sensory conflicting cues. They either enhance the vestibular cues or reducing visual motion cues.

2.1 Physical movement

As explained in the context paragraph, the lack of physical movement appropriate to the VR scene movement is a cause of VIMS. Therefore, the "direct" way to reduce cybersickness is to let users make physical movements. A walking-in-place method has been developed to allow users to physically move their legs [12] but the pseudo walking may not efficiently provoke pertinent self-motion in the vestibular system. Locomotion simulators further allow users to walk as in a real life within a restricted zone during VR experience, e.g. an omnidirectional tread-mill system [10]. However, the natural walk may not be guaranteed due to the latency of the mechanical system. In addition, this kind of solutions can be expensive and not suitable for most users with personal usage.

2.2 Physiological stimulation

Human vestibular system sensation can be altered though galvanic stimulation [14] to feel physical acceleration or balance changes. Therefore sensory conflict between visual and vestibular information can be decreased during VR experience. When providing vibration and electroshock to the legs, users can also feel pseudo physical walking motion [15]. However, these solutions require extra hardware and are intrusive.

2.3 Navigation parameters control

In order to avoid extra hardware, researchers have turned to software control. VR applications can be designed to actively alter user navigation parameters in order to reduce visually induced self-motion and VIMS. The user locomotion acceleration and speed can be adapted [4] or replaced by carefully calibrated automatic navigation [20]. The disadvantage is that users can no longer navigate freely with these counter-measures and the quality of navigation in VR can be reduced.

2.4 Visualization modification

Also on the software level, VR applications can be designed to actively alter user visualization. The insertion of a virtual nose as a static reference has been proposed as a VIMS counter-measure [21]. The static virtual nose can reduce the illusion of self-motion but may have a negative impact for user's immersion.

To reduce the VIMS during VR navigation, a radical approach has been proposed to blur the visual scene during rotating navigation [6]. The blurring effect is easily perceived by users and the consequence is a reduction in immersion.

It has been known that visually induced self-motion perceived by users is mainly induced by visual motion seen in the peripheral FOV [16]. A decrease of the FOV in virtual environment through VR headset can reduce the perceived self-motion [5]. Based on these principles, dynamic reductions in users' FOV has been developed as a VIMS counter-measure [1, 9]. When the user is stationary in the virtual environment, the full FOV is enabled and the entire screen is displaying virtual environment. Whereas during the navigation, FOV is reduced by displaying the frontal view in a limited viewport. Unfortunately, this method occlude the peripheral vision and can decrease the degree of immersion.

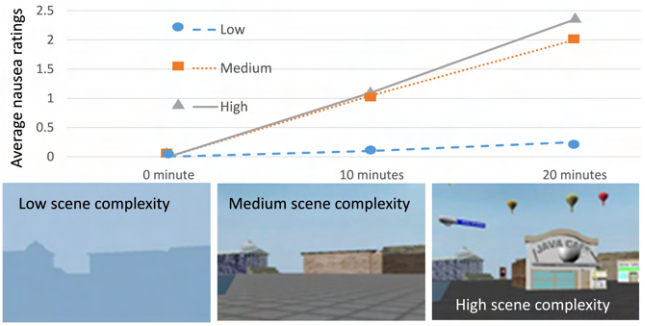


Figure 2: Effects of reducing VR scene complexity on rated nausea.

2.5 Geometric processing of virtual scene

Recently geometric processing of virtual scenes for reducing optic flow appeared in the literature. This kind of method is passive and will not degrade user navigation nor visual perception in the virtual world. For example, the part of the virtual environment seen in the peripheral FOV by users was deformed geometrically along the navigation direction and the visually perceived optic flow has been shown to be significantly reduced [13]. The advantage of this approach is that the degree of immersion is not affected since user FOV is maintained and user navigation control are maintained.

However, even though deformation is temporary, developers of VR systems or users may still have conservative views. In this paper, a less intrusive approach of geometric processing to reduce VIMS is proposed. Instead of deformation, the method simplifies geometrically the virtual environment according to user navigation. Simplification is not new and has been used to improve the performance for rendering [8]. This suggests that the VR application designers are likely to be more receptive to a geometry simplification method that can significantly reduce VIMS. The correlation between the scene complexity and visually induced motion sickness has been proposed in the literature [18, 19]. In this paper, two studies are presented. Study 1 confirms the significant reduction of VIMS by reduction the VR scene complexity. Study 2 proposes the geometric simplification methods and the significant reductions in optic flow vector magnitudes.

3 Study 1 – Effects of reducing VR scene complexity on VIMS

Twenty-four participants were randomly assigned to three 20-minute VR navigation journeys. The navigation paths and the basic VR scenes were the same across the three journeys except the texture mappings of VR objects were manipulated to provide VR scene complexity of low, medium and high levels (fig. 2).

Results indicated that as the VR scene complexity increased from low to medium, rated nausea significantly increased ($p < 0.05$, ANOVA) but there was no significant increases when the scene complexity increased from medium to high. Study 1 suggests that reducing VR scene complexity can reduce VIMS. However, it also indicates that the effects are not linear and there is room for fine manipulation and optimization. Hence, we conducted Study 2.

4 Study 2 - Dynamic scene simplification for reducing optic flow

Since the optic flow in the peripheral FOV is a main cause of VIMS [7, 11, 16], we propose an original approach to reduce peripheral optic flow by simplifying virtual scene dynamically. The idea is to dynamically and temporarily simplifying the geometry of the surrounding virtual scene during navigation so that the relative motion of the scene perceived in the user peripheral vision is reduced. When a user is navigating, the part of environment located in the

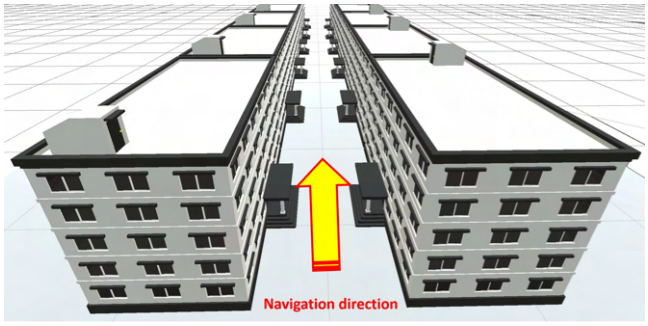


Figure 3: Virtual scene is a street with buildings on two sides.

user peripheral vision will be simplified. In the followings subsections some details are presented: an experimental scene, geometric simplifications applied to the scene and rendered images synthesis.

4.1 Scene creation

For prototyping a proof of concept a virtual scene is created (fig. 3) in order to further experiment the geometric simplification. The scene consists of buildings duplicated on the both sides of the street along which the navigation will be realized.

4.2 Geometric simplification

The geometric simplification was applied on each building manually according to the navigation direction. Following the concept of the CSDV [17, 18], spatial frequency along the directions of navigation were simplified. In figure fig. 4 the simplification of the building is illustrated. On the frontal façade, windows of the same floor are merged into a unique large window. Because the windows of the same floor are aligned with the navigation direction and their relative motion perceived visually by users will cause high self-motion. In addition, the two pillars at the gate are removed. The windows on the lateral side of the building are completely removed since they are less important for the visual fidelity of the building. Such geometric simplification can be automated in future work according to formulation of CSDV.

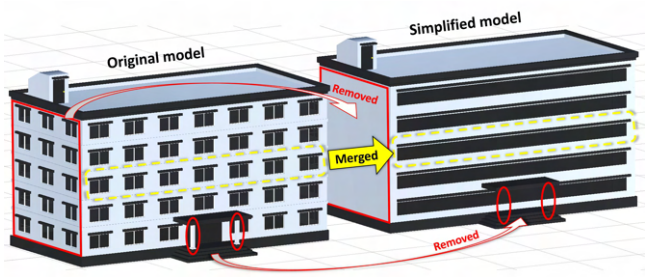


Figure 4: Comparison between original and simplified buildings.

4.3 Synthesis of original and simplified scenes

Figure 5 illustrates the pipeline of image synthesis. Two virtual cameras were used for rendering respectively images of central (original) scene (fig. 5.a) and images of simplified scene (fig. 5.b). The images of original scene are used to generate a circular mask (fig. 5.c) that will finally mask the center of the images of simplified scene (fig. 5.b). The resulted images (fig. 5.d) rendered to users are actually simplified scene images except for the circular center being original scene images. The radius of the circular mask is determined by the angle of frontal field of view of users.

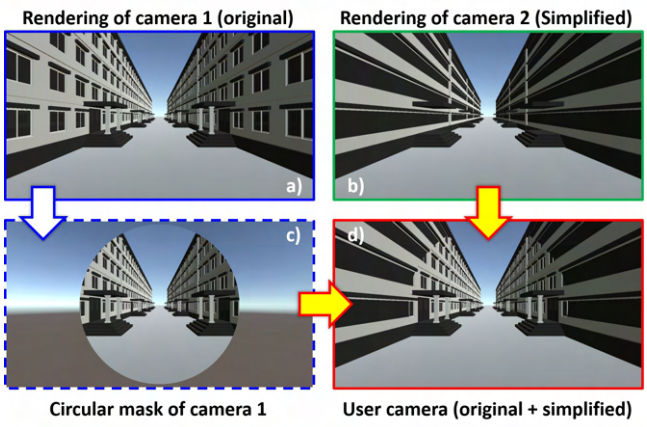


Figure 5: Rendered image synthesis for original and simplified scenes.

4.4 Experimentation and optic flow analysis

The optic flow patterns with and without geometric simplification have been analyzed. Figure 6 illustrates the optic flow motion vectors. Flow vector magnitudes in the peripheral visual field were significantly reduced by half from an average of 10.4 pixels to 4.5 pixels ($p < 0.05$, paired-t tests).

4.5 Discussion

In 2001, the same author reported a predictive metric called "spatial velocity (SV)" for VIMS. SV was defined as the dot product between navigation velocity (V) and the spatial frequency (S) of the VR scene along the same direction of V [18]. This "SV" has been formulated into CSDV which is predictive of VIMS. The SV formula can be integrated with the current geometric simplification method so as to dynamically calculate the best way to simplify the spatial frequency of VR scene for the reduction of VIMS.

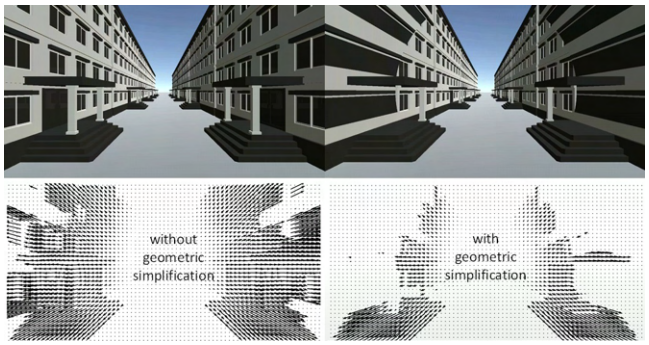


Figure 6: Optic flow analysis on the original (left) and simplified (right) scenes.

5 Conclusion

In this paper, two studies are presented. First, effects of reducing VIMS by reducing VR scene complexity are reported. Second, a geometric simplification method is proposed to reduce optic flow in VR simulation. A VR application has been prototyped to simplify geometrically the virtual scene seen in the peripheral field of view by users. Optic flow has been analyzed on the rendered images on both original and simplified scenes. Geometric simplification can significantly reduce the optic flow seen in the peripheral field of view of user. This investigation confirms the potential effectiveness

of the geometric simplification on visually induced self-motion in VR.

Although the current version of the geometric simplification is a proof-of-concept prototype, the method can be fully automated with further development. Future work to integrate CSDV into the geometric simplification model in order to determine the best way to simplify the scene for reducing VIMS is desirable. Due to difference among human individuals, the human perception thresholds will be explored to optimize the simplification levels.

ACKNOWLEDGMENTS

This work was supported by French government funding managed by the National Research Agency under the Investments for the Future program (PIA) grant ANR-21- ESRE-0030 (CONTINUUM).

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Geometric deformation for reducing optic flow and cybersickness dose value in VR

R. Lou [1], R. H. Y. So [2] and D. Bechmann [3]

[1]LISPEN EA 7515, Arts et Metiers, UBFC, HESAM, Institut Image, France
[2]Department of Industrial Engineering and Decision Analytics, Hong Kong University of Science and Technology, Hong Kong
[3]ICube, Université de Strasbourg, CNRS, France

Abstract

Today virtual reality technologies is becoming more and more widespread and has found strong applications in various domains. However, the fear to experience motion sickness is still an important barrier for VR users. Instead of moving physically, VR users experience virtual locomotion but their vestibular systems do not sense the self-motion that are visually induced by immersive displays. The mismatch in visual and vestibular senses causes sickness. Previous solutions actively reduce user's field-of-view and alter their navigation. In this paper we propose a passive approach that temporarily deforms geometrically the virtual environment according to user navigation. Two deformation methods have been prototyped and tested. The first one reduces the perceived optic flow which is the main cause of visually induced motion sickness. The second one encourages users to adopt smoother trajectories and reduce the cybersickness dose value. Both methods have the potential to be applied generically.

CCS Concepts

• ***Computing methodologies*** → ***Virtual reality; Perception; Mesh geometry models;***

1. Introduction

Virtual reality (VR) applications are no longer confined to gaming. Cheaper and better VR hardware has encouraged more and more applications in workplaces. Many novice VR users have not yet got used to navigation and perception in virtual environment and they can feel discomfort during their virtual experience due to visually induced motion sickness (VIMS). According to the sensory conflict theory, VIMS is provoked during a VR experience when humans perceive incoherently self-motion through vision and vestibular senses. Instead of moving physically, VR users send commands using devices (e.g., gamepad) to move in virtual worlds. Users can feel visually induced self-motion but they do not feel any movement according to their vestibular systems. This incoherent movement perception can provoke cybersickness among susceptible users which is half of the world population.

Two objective measures have been shown to influence VIMS: the optic flow generated from visualized images [JFR04] and the cybersickness dose value (CSDV) [So99] generated by navigation. The optic flow is motion of light seen in human eyes when human watch illuminated objects moving. It is represented by a vector field in which the light pattern velocity at each point of the field of view (FOV) is quantified. The VR immersion will let users to absorb completely the generated optic flow. The CSDV is related to the acceleration and exposure time during navigation and jerky trajectories will enhance the acceleration suffered by users.

2. Related work

Various VIMS counter-measures in VR can be found in the literature to reduce the self-motion differences perceived by vestibular and visual senses. They either enhance the vestibular sensation or reducing visual sensations.

Locomotion simulators allow user to walk as in a real life in a restricted zone during VR experience, e.g. an omnidirectional treadmill system [FCSE13]. Human vestibular system sensation can be altered though galvanic stimulation [MAA*05] to feel physical acceleration or balance changes. These solutions can be harmful, complicated or expensive for personal usage.

On the software level, VR systems can actively alter either user visualization or navigation. To reduce the VIMS during VR navigation, the user field of view (FOV) can be decreased dynamically [FF16], the user locomotion speed can be adapted [Argelaguet 2014] or replace by carefully calibrated automatic navigation [WCM19]. These approaches can reduce the quality of immersion or the navigation controls.

In this paper an original approach is proposed on the software level to deform geometrically the virtual environment according to the user navigation. Our method is passive and will not degrade user navigation nor visual perception in the virtual world. Actually the deformation is applied on the virtual environment passively and we do neither alter actively the user navigation nor visualization. Two deformation approach have been devised and prototyped. The first

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one allows to reduce the optic flow perceived in the scene visualization and the second one allows user to improve their navigation trajectory and reduce the cybersickness doses value (CSDV).

3. Scene deformation for reducing optic flow

The first approach consists of dynamically and temporarily deforming the geometry of the surrounding virtual scene during navigation so that the relative motion of the scene perceived in the user peripheral vision is reduced. The idea is to encapsulate the virtual environment into a regular grid to deform as a whole [SP86]. When a user is navigating, the part of environment located in the user peripheral vision will be deformed, i.e. compressed in the navigation direction. This approach has been firstly proposed and experimented in [LC19] and the participants felt subjectively a reduced navigation velocity in the deformed scene.

This method has been further investigated in order to analyze the generated optic flow that is related to visually induced self-motion [JFR04]. The optic flow has been analyzed on the rendered images both for normal and deformed scenes during navigation (fig. 1). We discover that the Scene deformation can significantly reduce the peripheral optic flow in the visualized images ($p<0.001$, paired t-test) without changing the optic flow at central view.

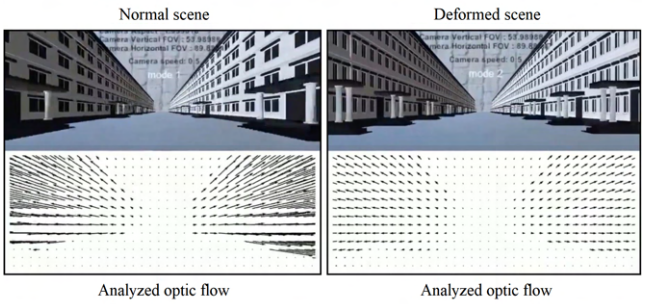

Figure 1: *Optic flow comparison*

4. Scene deformation for reducing CSDV

The second approach aims to deform the environment so that user can realize smooth navigation trajectories. Since users express their intention of locomotion through input devices and the visual perception of the virtual environment is limited by the FOV, users realize jerky navigation trajectories to avoid collision with the obstacles in virtual environment. An experimental virtual environment composed by walls has been designed (fig. 2.a). According to the location of user the nearby walls are deformed dynamically in order to facilitate the navigation and minimize the collision between user and the walls (fig. 2.b. Two user positions have been shown and the green spheres are safety buoys to trigger the wall deformation before the real collision between user and walls.

Two navigation trajectories have been realized respectively in normal and deformed scenes (fig 2.c) and are interpolated by cubic polynomials so that the second derivatives (acceleration) can be calculated (fig. 2.d). The trajectory realized in deformed scene is much smoother and the acceleration peak is lower. The CSDV proposed in [So99] has been computed and the ratio of CSDV in deformed scene to normal scene is 0.49.

5. Conclusion

This paper proposes the use of geometric deformation of the scene to reduce motion sickness in VR. Two deformation approaches have been implemented and analyzed. The first approach significantly reduces the optic flow perceived in the rendered images. The second approach can guide users to adopt smoother navigation trajectories so that the cybersickness dose value (CSDV) is reduced by half. These investigations confirm the effectiveness of the geometric deformation to reduce motion sickness in VR. In the future, the first approach will be updated to cover rotational navigations. Both methods can potentially be implemented in a generic way through a deformation engine. The challenge is to determine levels of deformation. Future work to modify CSDV to a predictive model so as to estimate the optimal deformation parameters are desirable.

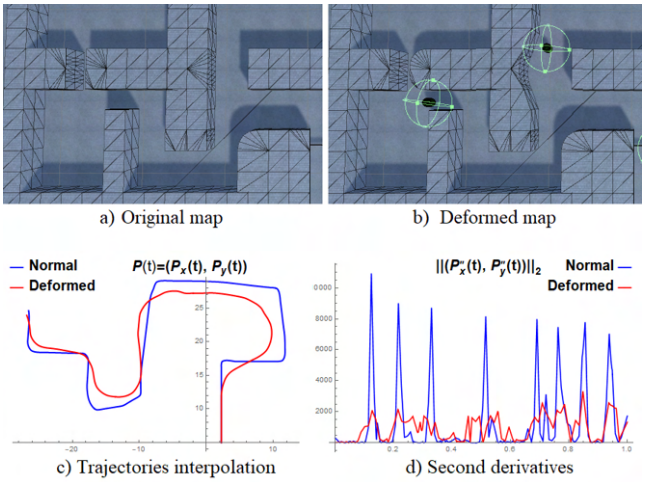

Figure 2: *Navigation trajectories comparison*

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Geometry deformation for reducing cybersickness in VR

Ruding Lou[1]

[1]LiSPEN, Arts et Metiers, Institut Image, Chalon-sur-Saone, France

Résumé

Virtual reality (VR) technologies became more and more widespread for a couple of years as they got more and more mature. The accessibility to VR highly increased thanks to recent low-cost commercial VR head mounted display systems and easy-to-use development toolkits. One important and well-studied human perception issue is related to motion sickness or cybersickness. In this paper we are dealing with case when users feel a visually induced induced self-motion that are not felt through their vestibular systems. This incoherent movement perception provokes cybersickness to the users.

To tackle this issue, we present in this paper a novel method to reduce cybersickness through reducing visually induced self-motion by processing geometrically the virtual scene while navigating. The first prototype of geometry deformation applied on virtual building appearing in the peripheral vision of user has been implemented and experimented. The feedback from the experiment participants shows that the visually induced self-motion is reduced and the navigation quality and presence level are guaranteed.

Mots clés : geometry processing, mesh deformation, virtual reality, cybersickness

1. Introduction

Virtual reality (VR) technologies became more and more widespread for a couple of years as they got more and more mature. The accessibility to VR highly increased thanks to recent low-cost commercial VR head mounted display (HMD) systems and easy-to-use development toolkits. These technologies found strong applications both in professional activities such as virtual product engineering and in personal activities such as video games.

The last progress in VR technologies does not concern only the performance and realism of computer simulation but also human perception aspects. One important and well-studied human perception issue is related to motion sickness or cybersickness. Since VR HMDs are much more used than ever, cybersickness problem resolution is of primary concern. According to the well-known sensory conflict theory [Rea78], cybersickness is provoked during a VR experience when humans perceive incoherent movements by different physiological sensors : eyes (visual), ears (audio), vestibular system (physical), muscles (spent effort), etc. Usually instead of moving physically, users send commands using devices (e.g., joysticks) to navigate in virtual worlds. Therefore, users can feel very realistic movement through perceived visual information but they do not feel any movement according to their vestibular system.

To tackle this issue, we present in this paper a novel method to reduce cybersickness through an original approach : we propose to reduce visually induced self-motion deforming geometrically the surrounding virtual scene during user navigation. The proposed approach will allow reducing visually induced self-motion and so lower cybersickness. The approach is proposed for the case users can perceive the virtual world solely by vision and they do not get any feedback by other senses (haptic, audio, etc.). In this condition, we suppose that the major cause of the self-motion induced by users is the visually perceived relative movement of objects in the lateral field of view (FOV). Therefore, the proposed approach will reduce the relative movement of objects seen in the lateral FOV of users by deforming geometrically the virtual scene, in order to reduce the perceived navigation self-motion.

The rest of the paper is organized as following : the literature review about different ways to deal with the motion sickness in virtual reality (section 2) ; The general concept of the proposed approach and hypothesis (section 3) ; The development of the first prototype and its pilot study (section 4) ; The conclusion and perspectives of this work (section 5).

2. State of the art

A huge piece of work in the state of the art has been done to reduce cybersickness and they can be categorized into the following approaches.

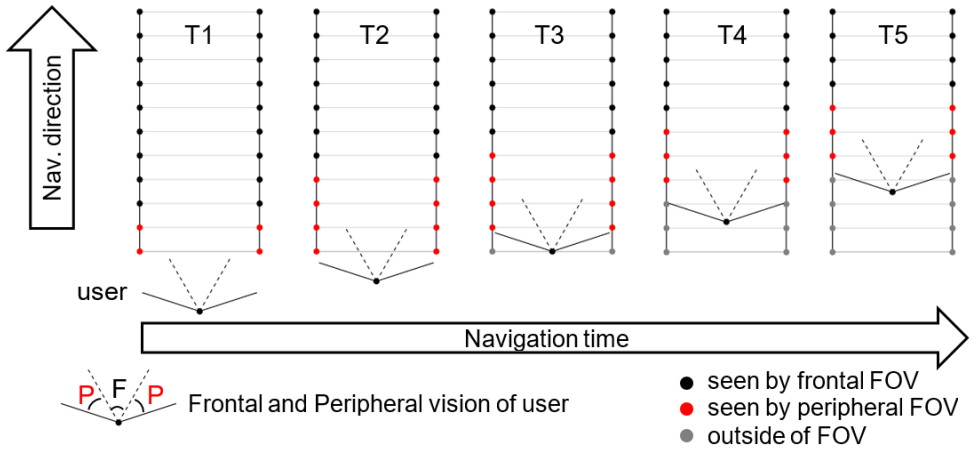

Figure 1 : *Illustration of user navigation in virtual environment and the frontal and peripheral FOV.*

2.1. Augmenting physical movement during VR experience

The reason of having motion sickness explained in the context paragraph consists in the lack of physical movement that can be perceived by the vestibular system. Therefore, The "direct" way to reduce cybersickness is to let users make physical movements according to the navigation mode [WO90]. For example, instead of using joystick to interpret movement for walking virtually in an immersive environment, users can physically move their legs to walk in place, which approximates real walking [WO90] [RSS*02]. Different from walking in place, "omnidirectional treadmill" systems have been proposed to let users adopt a similar gait as in real walking [FCSE13]. These solutions are usually ideal and consistent with the cause of cybersickness but usually they are expensive and not suitable for most public users.

2.2. Physiological enrichment

Other works have been proposed to provide physiological stimuli to users. For example when providing vibration and electroshock to the legs, users can feel pseudo physical walking movements without moving [MAA*05]. It is also possible to achieve walk navigation by using galvanic vestibular stimulation [PPCM15]. The drawbacks of this kind of approach are that users have to wear complementary devices and the physiological stimuli are not fully comfortable for practical daily use.

2.3. VR interaction control

Another way to reduce the sensory conflict is to adjust the navigation parameters. Typically, the navigation acceleration are re-adjusted in order to reduce the difference between the movement perceived by the eyes and the vestibular system [PCM18]. The approach proposed in [Arg14] consists in adapting the navigation speed and trajectory based on the spatial relationship between the user and the environment. But this may reduce the navigation quality since the user's intention on the navigation parameters (speed, navigation & trajectory) is not ensured.

2.4. Peripheral visual field control

Rogers et al. [RRW17] showed that most of the self-motion perceived visually by users is mainly based on the relative movement of the objects that are seen in the peripheral field of view (FOV). Therefore, it is possible to reduce cybersickness by reducing the FOV [BFG17]. When the user is stationary in the virtual environment, the full FOV is enabled and the entire screen is displaying virtual environment. Whereas during the navigation the partial FOV is enabled by displaying the frontal view in a limited viewport. The reduction of the FOV removes the lateral vision and only lets users to see what is in front of him/her. The shortcoming of this approach is that it decreases the degree of immersion if the FOV is strongly reduced. Other approach involves adding a blur effect during rotating navigation in order to reduce the induced self-motion [BMMF17]. The blurring effect is easily perceived by users and the consequence is the degree immersion is seriously reduced.

2.5. Position of the proposed approach relative to the state of the art

The approach proposed in this paper deals with the sensation of illusory self-motion that is induced by the visual flow in peripheral vision. The proposed approach will overcome shortcomings present in certain previous works. In compare with the previous work [PCM18] [Arg14] our approach does not modify the navigation intention of the user (speed, acceleration and trajectory). Unlike the approach proposed in [BFG17] our approach will let user the full FOV available during the VR experience. In the contrary with the approach proposed in [BMMF17] all rendered images are clear with our approach.

Our approach consists in reducing the relative movement quantity perceived visually in the lateral FOV. Unlike the methods "VR interaction control", our approach keeps the

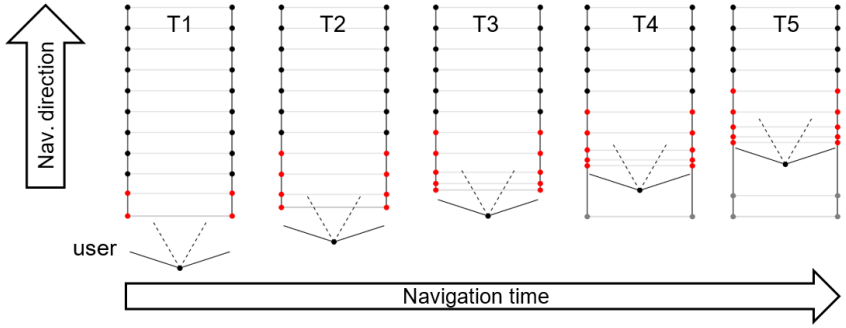

Figure 2 : *Deformation of virtual environment seen in the peripheral FOV.*

user's intention on the navigation parameters in order to ensure navigation quality. Unlike the methods "Peripheral visual field control", the degree of immersion is ensured with our approach by using the entire FOV and keeping clear vision.

3. Proposed approach

During virtual navigation in virtual environment different virtual parts are seen by the user. These seen parts can be categorized into three types : seen in the frontal FOV, seen in the peripheral FOV and outside of FOV. The virtual navigation is illustrated in figure 1. The user navigates in the virtual environment that is modelled by the rectangle surrounded by points. The user moves in the navigation direction and different instances (T1 – T5) are illustrated. The look direction of the user is aligned with the navigation direction and its FOV is represented by the two solid lines. The FOV is then segmented into three fields by two dashed line : left peripheral, frontal and right peripheral FOV. According to the different positions of the user in different instances (T1 - T5), the part of virtual environment seen in the frontal FOV is represented by black points, the one seen in the peripheral FOV is represented by red points and the one outside of the FOV is represented by gray points.

The self-motion induced by user is due to the relative movement of the virtual environment perceived by user vision. According to previous studies [BSW11] [Rie11], the induced self-motion is essentially due to the relative movement of the environment seen in peripheral FOV (represented by red points in figure 1). Therefore, our approach will deform the environment in order to somehow "compress" the geometry visible in the lateral FOV so that it seems moving slower than the frontally viewed part. Figure 2 shows the deformation of the virtual environment especially for the part that are seen in the peripheral FOV. The red points that are seen in the peripheral FOV move in the same direction with the user. The speed of the red points is increased progressively but always smaller than the speed of the user. Once the red points move out of the vision of user they become gray and can be reset to their initial positions.

When user navigates in an environment the various objects are not structured in a regular space which can be easily categorized in a similar way as the black, red and gray points (figure 1). Moreover, the deformation method should be able to deform simultaneously several disconnected meshes. Therefore, the most appropriated deformation method that is anticipated is the cage-based deformation [NS13]. Figure 3 illustrates the cage generation on the navigation environment for the user. The vertices of the generated cage are categorized and colorized (black, red and gray) according to the FOV of the user, in a similar way illustrated in figure 1. In order to deform the virtual environment according to the user navigation direction, the cage (vertices & edges) will be modified in a similar way than the one presented in figure 2

3.1. Hypotheses

Several research hypotheses have been identified along the objectives defined above.

H1 : There is a frontier to separate the frontal and lateral view according to various navigation parameters : navigation direction and speed, user gaze, etc.

H2 : The geometrical deformation of the scene can change the perceived self-motion.

H3 : The reduced perceived self-motion reduces the motion sickness.

H4 : When deforming the scene for the part visible in the lateral FOV the navigation quality and degree of immersion will not be significantly impacted.

3.2. Scientific and technical barriers

The major challenges to prove the hypotheses identified above are analyzed :

B1 : What are the most appropriate subjective and objective evaluation tools for motion sickness ?

B2 : How to compute in real time the frontier between frontal and lateral FOV ?

B3 : How to deform geometrically in real time the scene according to the different linear/angular speed and acceleration of the user's navigation ?

B4 : How to adapt the deformation parameters according to the motion sickness degree ?

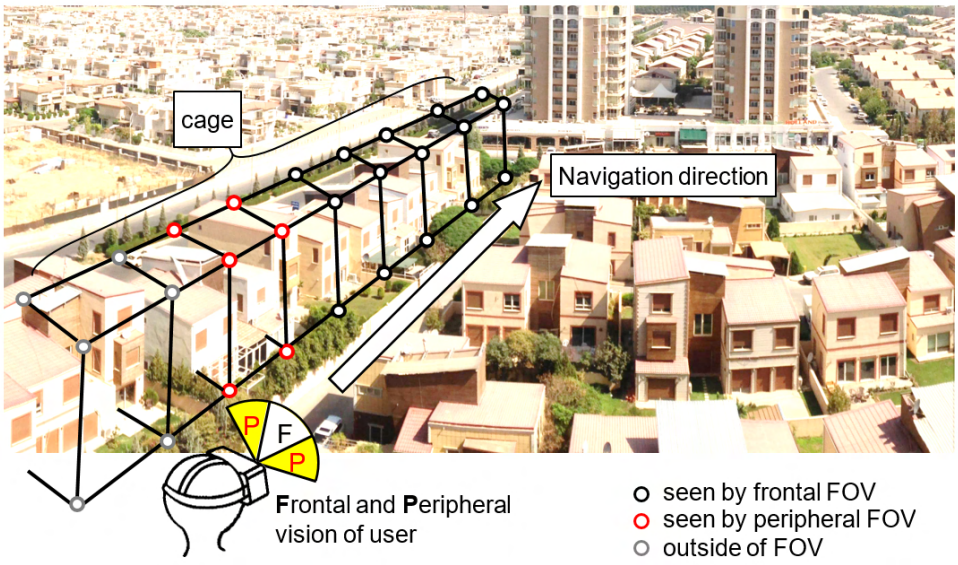

Figure 3 : *Cage generation and segmentation of the navigation environment.*

4. Pilot study

A first prototype of our approach has been designed and implemented [LC19]. A pilot experimentation about this prototype has been conducted . It consists in the case where user navigates in a straight line with constant speed. The virtual objects on the two sides of the navigation path are deformed to reduce the relative movement perceived by the user. A pilot experimentation about this prototype shows that the navigation quality and degree of immersion are not impacted. This pilot study shows that the proposed method is efficient and worthy to investigate.

4.1. Implementation of prototype

The literature is broad regarding mesh deformation but some specific requirements were identified in our case :

- everything in the peripheral FOV should be deformed in a uniform way according to the direction of navigation and the distance to the observer ;
- the deformation should be invariant relative to the mesh tessellation ;
- the algorithm should be able to deform simultaneously several disconnected meshes.

Based on these requirements, the adopted mesh deformation method is the lattice-based deformation method presented by Sederberg and Parry [SP86]. Briefly speaking, starting from multiple meshes, a global bounding box is computed in order to generate lattices of regular sizes. The vertices of the lattices are then defined as control points for the 3-dimensional Bézier solid included in the bounding box. Therefore, when moving these control points, the included Bézier solid is deformed, as well as all the meshes that are inside. Figure 4.a illustrates the virtual environment used in the pilot study. It consists of a street with buildings on its two sides. The user (observer) goes straight through the buildings in a constant speed. The lattices with control points are computed and represented by red points and orange edges. The three pictures (figure 4.a, b and c) show respectively three instances in chronology and the initial position of the observer is shown in the figure 4.a. When the observer navigates the control points are also moved and their displacement will yield the buildings deformation (figure 4.b and c). The detail of the implemented deformation algorithm is presented in [LC19].

Figure 5 shows the first person view of the observer navigating in the between the buildings. The normal buildings are used during the navigation in figure 5.a. The geometrical deformation is applied on the buildings during the navigation in figure 5.b. The buildings seen nearby the user are deformed to reduce the relative movement that can be perceived visually by the user (figure 5.b).

The proposed method has been implemented under Unity3D and displayed in an HTC Vive HMD with the environment shown in figure 4. Navigation in the virtual scene lasts less than 30s. A first experimentation has been realized.

4.2. Experimentation

20 subjects aged from 20 to 50 were asked to voluntarily test our approach and compare two navigation modes (figure 4.a and b). After navigating twice in both modes, each subject were asked to answer a questionnaire containing seven questions, based on the Witmer-Singer presence questionnaire [WS98]. This questionnaire allows to evaluate the navigation quality and degree of immersion during virtual experience. At end the subjects were also asked to compare the perceived navigation speed in the two modes.

According to the experimentation results, the adopted approach does not produce significant difference both in terms of navigation quality and presence level and the self-motion

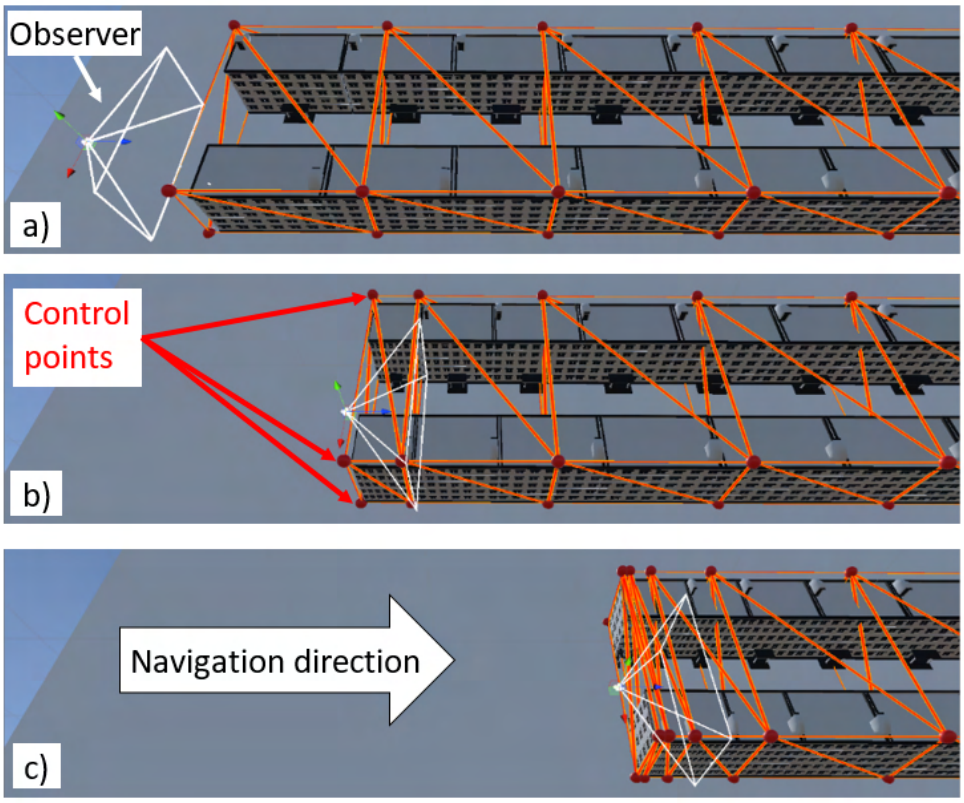

Figure 4 : *Virtual observer navigation through the buildings under geometrical deformation using a lattice-based approach.*

perceived by users were lower in the mode with deformation than the normal scene.

5. Conclusion and perspectives

In this paper an approach using geometry deformation to reduce motion sickness during VR experience is proposed. According to the literature review it is original to use knowledge of geometry modelling in VR motion sickness problem solving.

A first prototype has been implemented and experimented. There are still many research questions to answer and technical problems to solve. For example, user looks around during navigation, the navigation is other than advancing : translation, rotation, etc. The results of the experimentation shows that the visually induced self-motion has been reduced without significant difference about navigation quality nor presence level.

The positive results of this pilot study shows that the proposed approach in this paper is worthy to be more investigated. All the research hypothesis (section 3.1) and scientific & technical barriers (section 3.2) will be addressed in the future work.

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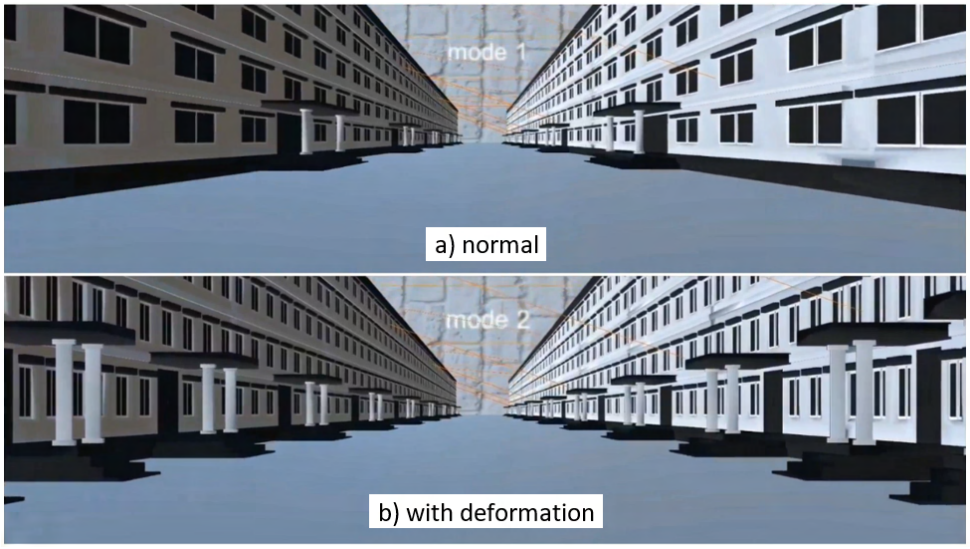

Figure 5 : *Virtual observer navigation through the normal buildings (a) and buidings under geometrical deformation using a lattice-based approach.*

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Reducing Cybersickness by Geometry Deformation

Ruding Lou* Jean-Rémy Chardonnet†

LISPEN EA 7515, Arts et Métiers, UBFC, HESAM, Institut Image, 2 rue Thomas Dumorey, Chalon-sur-Saône, France

ABSTRACT

One major and well-known issue that occurs during VR experience is the appearance of cybersickness, which refrains users from accepting VR technologies. The induced cybersickness is due to a self-motion feeling that is produced when users see objects moving in the virtual world. To reduce cybersickness several methods have been proposed in the literature, however they do not guarantee immersion and navigation quality. In this paper, a new method to reduce cybersickness is proposed. The geometric deformation of the virtual model displayed in the peripheral field of view allows reducing the self-motion perceived by the user. Pilot test results show that visually induced self-motion is reduced with a guaranteed immersion quality while the user navigation parameters are kept.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality; Computing methodologies—Computer graphics—Shape modeling—Mesh geometry models

1 INTRODUCTION

Virtual reality (VR) technologies became widespread for a couple of years as they got more and more mature. The accessibility to VR highly increased thanks to recent low-cost VR head mounted displays (HMD) and easy-to-use development toolkits. These technologies found strong applications both in personal and professional activities such as product engineering or video games.

The last progress in VR technologies does not concern only the performance and realism of computer simulation but also human factors aspects. One major human factor issue is related to cybersickness. Since VR HMDs are much more used than ever, cybersickness issue resolution is of primary concern. According to the well-known sensory conflict theory [6], cybersickness is provoked during a VR experience when humans perceive incoherent movements by different physiological sensors: eyes, ears, vestibular system, etc. Usually instead of moving physically, users send commands using devices (e.g., joysticks) to navigate in virtual worlds. Therefore, users can feel realistic movements through perceived visual information but they do not feel any movement according to their vestibular system.

To tackle this issue, we present here a novel method to reduce cybersickness through an original approach: we propose to reduce visually induced self-motion by deforming the surrounding virtual scene while navigating.

2 RELATED WORK

A huge piece of work has been done to reduce cybersickness and can be categorized into the following approaches.

The "direct" way is to let users make physical movements according to the navigation mode. For example, to virtually walk in an immersive environment, users can physically move their legs to walk in place, which approximates real walking [5]. Rather than walking in place, "omnidirectional treadmill" systems have been proposed to let users make similar efforts as in real walking [2]. These solutions are usually ideal and consistent with the cause of cybersickness but usually they are expensive and not suitable for most public users.

Other work proposed to provide physiological stimuli to users. For example when providing vibrations to the legs, users can feel pseudo physical walking movements without moving [4]. The drawbacks are that users have to wear complementary devices and the physiological stimuli are not fully comfortable.

Another way is to adjust navigation parameters: the navigation acceleration is continuously re-adjusted depending on the current user physiological state [3]. But this may reduce navigation quality since the user has no full control over the navigation parameters.

Rogers et al. [7] showed that most of the self-motion perceived visually by users is mainly based on the relative movement of the objects that are seen in the peripheral field of view (FOV). Therefore, cybersickness can be reduced by reducing the FOV [1]. However it decreases the immersion level if the FOV is strongly reduced.

In this paper, we contribute on past work by proposing an original solution for cybersickness by geometry deformation. Our approach allows reducing visually induced self-motion and so lower cybersickness, by keeping the full FOV and reducing the relative movement quantity perceived visually in the lateral FOV. The perceived navigation speed is thus reduced while ensuring navigation quality by preserving the relative motion perceived in the frontal FOV.

3 GEOMETRY DEFORMATION

Fig. 1 illustrates our approach to deform the geometry of the surrounding virtual objects (here a street bordered by buildings) when an observer moves virtually. The three pictures show the scene at three different moments in chronological order. The parts of the buildings coming into the observer peripheral FOV move also in the same direction of the observer.

3.1 Mesh Deformation Approach

The literature is broad regarding mesh deformation but some specific requirements were identified in our case: (i) everything in the peripheral FOV should be deformed in a uniform way according to the direction of navigation and the distance to the observer; (ii) the deformation should be invariant relative to the mesh tessellation; (iii) disconnected meshes should be deformed simultaneously. Based on these requirements, the adopted mesh deformation method is the lattice-based deformation method proposed by Sederberg and Parry [8]. Starting from multiple meshes, a global bounding box is computed in order to generate lattices of regular sizes. The vertices of the lattices are then defined as control points for the 3-dimensional Bézier solid included in the bounding box. Therefore when moving these points, the included Bézier solid is deformed, as well as all the meshes that are inside. The lattices generation for the virtual scene is illustrated in Fig. 1. The red spheres represent control points of the lattices and their displacement will yield the model deformation.

3.2 Navigation-driven VR Environment Deformation

It is necessary to define how navigation will drive the deformation. In fact, in our case, it will consist in moving the lattices control points according to the observer's navigation parameters. Here, considering the virtual scene of Fig. 1, we suppose that the observer

*e-mail: ruding.lou@ensam.eu

†*IEEE Member*, e-mail: jean-remy.chardonnet@ensam.eu

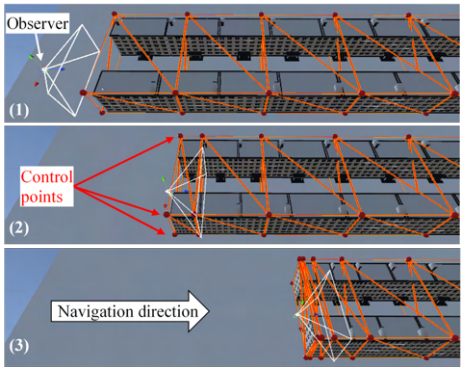

Figure 1: Virtual observer navigation through the buildings under deformation using a lattice-based approach.

navigation velocity ($\mathbf{v_n}$) is constant and his/her position ($\mathbf{p_n}$) is always on the medial axis of the street. By default each lattices control point has a null velocity so that the buildings are not deformed. During navigation, at each frame, they will move and so deform the buildings accordingly. The algorithm used to change the velocity of the control points ($\mathbf{v_c}$) is described in Alg. 1.

Algorithm 1 VR environment deformation

```
s ← lattice size
for all rendering frames do
  for all control points c with position p_c and velocity v_c do
    d_n ← v_n/||v_n||
    r ← 1 − ||(p_n − p_c) · d_n||/s
    if r > 0 then
      v_c ← r · v_n
    end if
  end for
end for
```

4 Experimentation and Results

The proposed method was implemented under Unity3D and displayed in an HTC Vive HMD with the environment shown in Fig. 1. The virtual street is 300m long and navigation in the scene lasts 20s.

20 subjects (2 females) aged from 20 to 50 ($M = 29.9$, $SD = 11.34$) were asked to voluntarily test our approach and compare two navigation modes. The first mode, named M1, is a normal navigation mode without any deformation of the virtual scene (considered as the reference) and the second mode, named M2, includes the deformation of the virtual scene. In both modes, navigation speed is constant. Half of the subjects were used to VR and the others not.

After navigating twice in both modes, each subject were asked to answer a questionnaire containing seven questions, based on the Witmer-Singer presence questionnaire [9]. For each question, a seven-point Likert scale was used to capture the subjects' responses. The questionnaire is composed of:

- Three questions about navigation quality in the two modes. The scores were summed to give a final score from 1 to 21.
- Three questions about the degree of presence in the two modes. The scores were summed to give a final score from 1 to 21.
- The last question compares the perceived navigation speed between both modes. The score varies from −3 (completely faster in M1) through 0 (equivalent speed) to 3 (completely faster in M2).

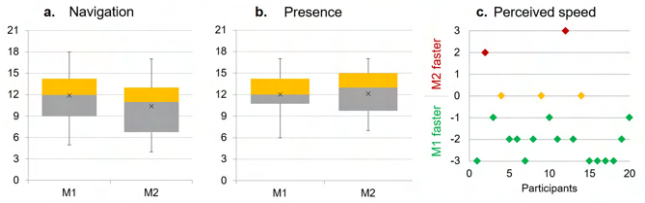

Figure 2: Navigation quality, presence and perceived speed.

A Shapiro-Wilk test showed all the data to be normally distributed. Regarding navigation quality, a t-test showed that there was no significant difference between both modes ($M_{M1} = 11.9$, $SD_{M1} = 3.61$; $M_{M2} = 10.4$, $SD_{M2} = 3.91$), $t(19) = 1.26$, $p = 0.22 > 0.05$ (Fig. 2a.), indicating that navigation quality is not affected by our approach. Regarding presence, a t-test showed that there was no significant difference between both modes ($M_{M1} = 12.05$, $SD_{M1} = 3.23$; $M_{M2} = 12.15$, $SD_{M2} = 3.01$), $t(19) = -0.12$, $p = 0.91 > 0.05$ (Fig. 2b.), indicating that presence is not affected by our approach. Finally, the perceived navigation speed was found to be higher in M1 than in M2 ($M = -1.4$, $SD = 1.70$) (Fig. 2c.), which may indicate that, with our approach and with longer tests, cybersickness could be reduced as visually induced self-motion is reduced.

5 Conclusion

In this paper a new approach was proposed to tackle cybersickness in VR by deforming the surrounding environment. The proposed approach does neither limit the FOV in the display system nor modify the navigation parameters. The deformation of the environment allows reducing the perceived navigation speed. A first experimentation showed that our approach does not impact navigation quality nor the presence level.

Future work will include further in-depth tests to assess our approach regarding cybersickness reduction, as well as extending our approach to deform the environment whatever the navigation mode (translation, rotation, fly, etc.) and on more complex situations.

References

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[7] C. Rogers, S. K. Rushton, and P. A. Warren. Peripheral visual cues contribute to the perception of object movement during self-movement. *i-Perception*, 8(6), 2017. doi: 10.1177/2041669517736072

[8] T. W. Sederberg and S. R. Parry. Free-form deformation of solid geometric models. *SIGGRAPH Comput. Graph.*, 20(4):151–160, 1986.

[9] B. G. Witmer and M. J. Singer. Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, 7(3):225–240, 1998.

ParisTech

ESPCI PARIS PSL

TITLE: INTELLIGENT REFLECTING SURFACES FOR BACKSCATTER TELECOMMUNICATIONS

Topic number : ***2022_014***

Field : Information and Communication Science and Technology, Physics, Optics,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: Physique sublongueur d'onde (SWAP)
https://www.institut-langevin.espci.fr/subwavelength_physics_swap
Research lab: Institut Langevin
Lab location: Paris
Lab website:https://www.institut-langevin.espci.fr/home

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: de Rosny Julien julien.derosny@espci.fr
Advisor 2: Ourir Abdelwaheb a.ourir@espci.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Recently, to increase the coverage and the capacity of telecommunication systems without densifying, without increasing the radiated Electro-Magnetic Field and spending energy on radio emissions, it has been proposed to deploy a new type of device called reconfigurable intelligent surfaces (RIS) . A RIS is an array of radiating elements that is not actively transmitting radio waves.
A RIS acts as an intelligent mirror for radio waves that is controlled by the network to improve the link budget of an ongoing wireless communication. In parallel, RIS have also been proposed to transmit data. In this case, a RIS is transmitting data to a receiver by backscattering ambient radio waves generated by a device or an antenna from the wireless network.
The idea of backscattering systems is to recycle the ambient field generated by some sources of opportunities such as TV or FM broadcast emitters . To transmit the information, the backscatter (BS) modulate its backscattering strength . Such a system is very low power because it only requires switching the impedance load of a backscatter.
Here we propose to use a RIS as a backscatterer in order to perform

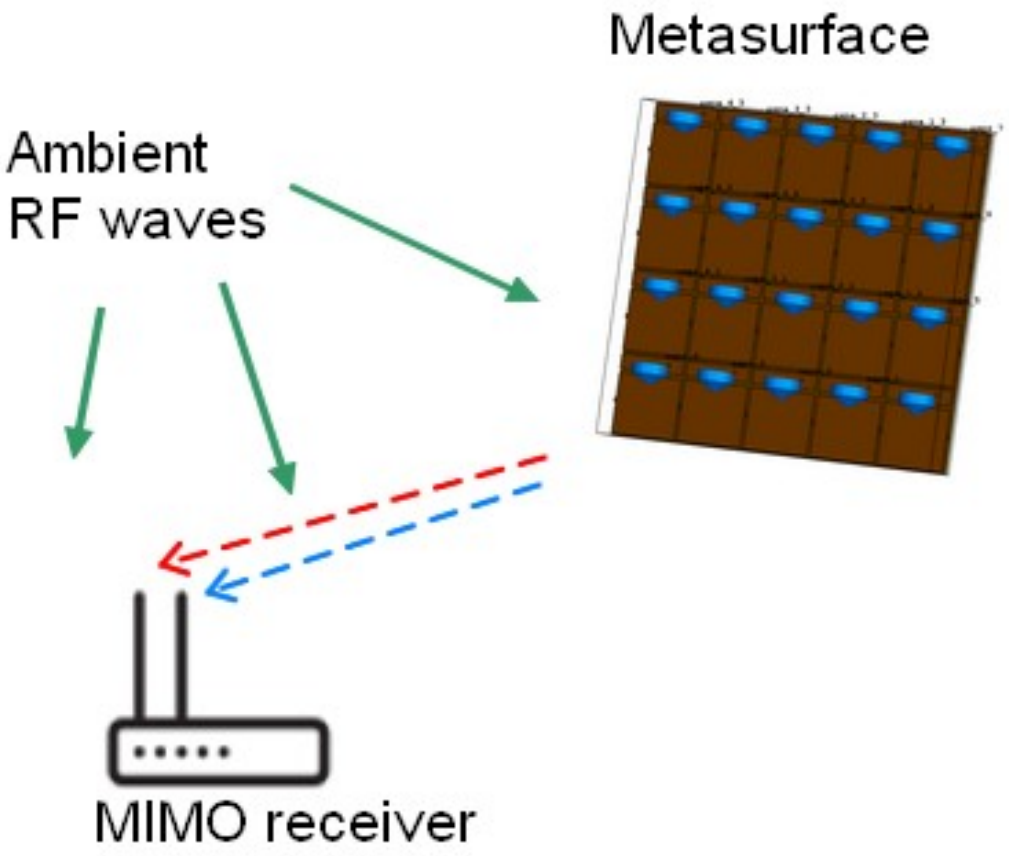
MIMO-like passive communications. Two aspects will be studied. The first one consists of using the RIS to improve the communication link in order for instance to increase the range. The second aspect that focuses on short-range communications consists of increasing the data rate thanks to the spatial diversity of the RIS. To answer to these questions, a first simple LoS model will be used. Based on this study a new RIS based on varicap will be developed. The RIS will be implemented in Gnuradio. The effectiveness of the metasurface will be validated experimental validations on different configurations.

Required background of the student: electromagnetism, physics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Renzo, M.D., Debbah, M., Phan-Huy, D. et al., "Smart radio environments empowered by reconfigurable AI meta-surfaces", J Wireless Com Network 2019, 129 (2019
2. Rachedi, K., et al., "Real-Time Ambient Backscatter Demonstration", IEEE INFOCOM 2019-IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS). IEEE, 2019.
3. R Fara, P Ratajczak, DT Phan-Huy, A Ourir, M Di Renzo, J De Rosny, "A prototype of reconfigurable intelligent surface with continuous control of the reflection phase", IEEE Wireless Communications 29 (1), 70-77
4. Romain Fara, D-T Phan-Huy, Abdelwaheb Ourir, Marco Di Renzo, Julien de Rosny, "Robust Ambient Backscatter Communications with Polarization Reconfigurable Tags", IEEE 31st Annual International Symposium on Personal, Indoor and Mobile Radio Communications 2020
5.

Illustrations :


Metasurface
Ambient
RF waves
MIMO receiver

ParisTech

ESPCI PARIS PSL

TITLE: AERODYNAMIC AND ELASTIC RESPONSE OF DRAGONFLY-INSPIRED FLAPPING WINGS

Topic number : ***2022_015***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: BIOMIM https://www.pmmh.espci.fr/Biomimetics-and-Fluid-Structure-Interaction
Research lab: PMMH - Physique et mécanique des Milieux Hétérogènes
Lab location: Paris
Lab website:https://www.pmmh.espci.fr/

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Godoy-Diana Ramiro ramiro@pmmh.espci.fr
Advisor 2: Thiria Benjamin bthiria@pmmh.espci.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Wings play a vital role in insect morphology, having to withstand a high number of wingbeat cycles throughout a lifetime, and develop aerodynamic forces for all the functions of insect flight: predatory behaviour, escape maneuvers, courtship, acoustics, etc. The study of the complex aerodynamic mechanisms and morphological features in insect wings is therefore crucial to the understanding of insect behavior (Bomphrey & Godoy-Diana, 2018). Moreover, the small relative size of the wings, and their lightweight, durable and flexible features represent an interesting area of development for bio-inspired aerial vehicles, and research into the biomechanics of insect flight can help the development of diverse industrial applications. Wing flexibility is a crucial ingredient in the functioning of flapping wings (Ramananarivo et al. 2011). The goal of the present PhD project is to characterize the effect of anisotropy in the wing rigidity in dragonflies (order Odonata) on aerodynamic performance, using a simplified model for the corrugation as well as the venation of the wings.

The hosting team at PMMH, ESPCI Paris has done preliminary work on an experimental setup dedicated to this problem (see figure), measuring

the aerodynamic response of model wings in hovering configuration and under an incoming flow in a wind tunnel. Here we propose to investigate this fluid-structure interaction (FSI) problem, where the aerodynamic problem is coupled with the structural dynamics of the wings, using fully-coupled FSI numerical simulations. The main global objective is thus to obtain a quantitative description of the effects of realistic flexural stiffness on the aerodynamic performance of flapping wings. The FSI study will be conducted in parallel to a new campaign of model experiments.

Required background of the student:

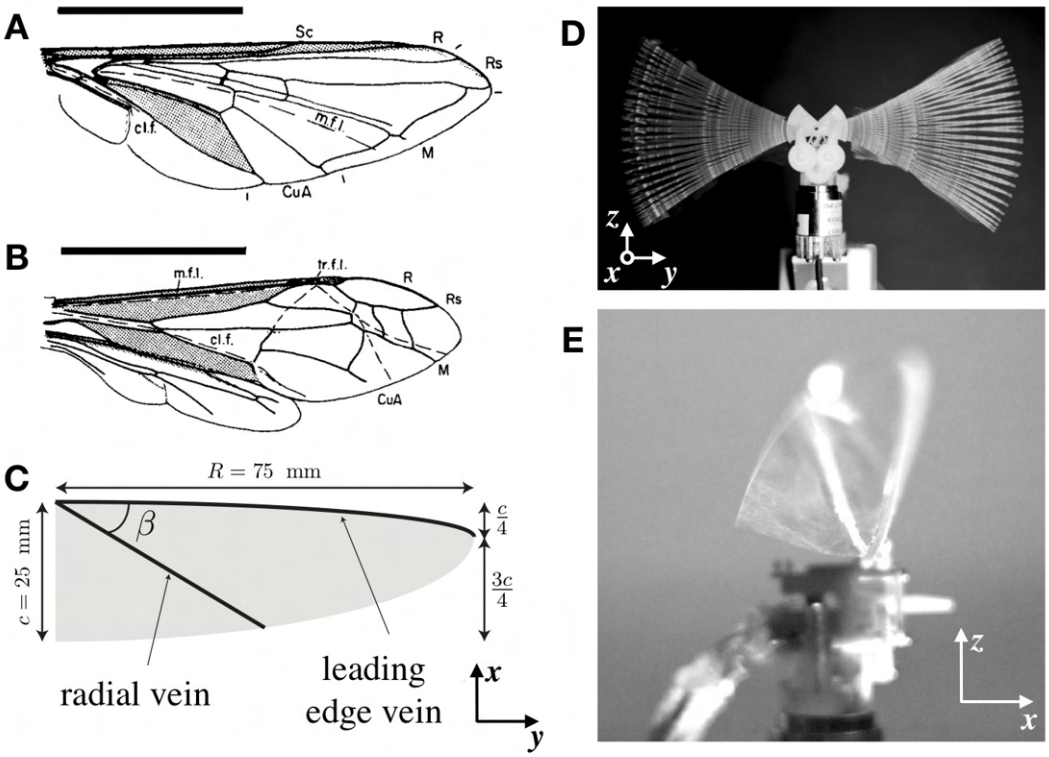
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. S. Ramananarivo; R. Godoy-Diana & B. Thiria. "Rather than resonance, flapping wing flyers may play on aerodynamics to improve performance", Proceedings of the National Academy of Sciences (USA), 108 (15), 5964-5969 (2011).

2. R. Bomphrey & R. Godoy-Diana. "Insect and insect-inspired aerodynamics: unsteadiness, structural mechanics and flight control", Current Opinion in Insect Science 30, 26–32 (2018).

3. R. Antier, B. Thiria & R. Godoy-Diana. "Anisotropic rigidity governs the dynamics of insect-inspired two-vein flapping wings" (submitted)
4.
5.

Illustrations :



(A) and (B) Two examples of the rigidity distribution in insect wings (Figures from Wootton, 1981). Supporting areas (stippled), deformable areas (unstippled) and flexion lines (dashed) in (A) *Syrphus ribesii* (Diptera); (B) *Vespula germunica* (Hymenoptera). m.f.l., median flexion line; cl.f., claval furrow; tr.f.l., transverse flexion line. Scale lines = 5 mm. (C) Model wing. (D) and (E) Frontal and side views, respectively, of the system mounted on the force sensor. In (D) several snapshots are superposed to illustrate the flapping wing motion (Figures from Antier et al. 2022).

ParisTech

ESPCI PARIS PSL

TITLE: ACTIVE COLLOIDAL GELS

Topic number : ***2022_016***

Field : Material science, Mechanics and Fluids, ,

Subfield: Softmatter

ParisTech School: ESPCI Paris - PSL
Research team: Active and Programmable Matter
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location: Paris
Lab website:https://www.gulliver.espci.fr

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Dauchot Olivier olivier.dauchot@espci.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Active Colloidal gels are made of a standard depletion induced colloidal gel, with micron sized colloids, among which a given fraction of the colloids are active particles. Active particles are catalytically powered colloids, which self-propel or exert forces when illuminated by light. When interacting together, they eventually develop collective dynamics. In the past 20 years, a large amount of work has dealt with the study of active liquids, for which the active units self-propel in a dilute phase and exhibit collective motion. Conversely, although driven solid architectures are common in living matter e.g. in our own tissues, where molecular motors stiffen and contract biopolymer networks, their physics remains poorly explored.

In the past three years we have tailored an artificial system that combines activity with colloidal gelation and demonstrated that activity reorganizes the gel in a way that persist for long times once activity is switched off. These intriguing results leave open a number of fascinating questions and open a brand-new avenue of research.

Examples of open questions are:
- What is the mechanism by which the active reorganization encodes its

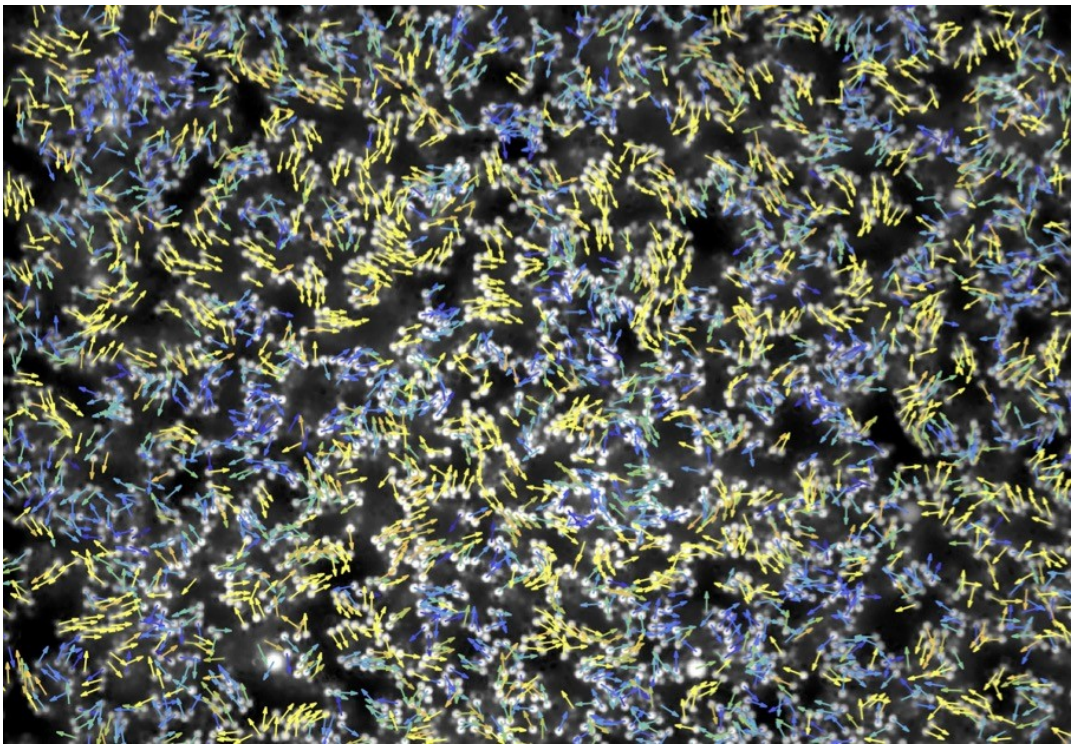
effect in the structure of the gel.
- Since the gel has a memory of the actuation, can we perform cycles of actuation to encode, and later decode some information in the structure of the gel?
- What is the mechanical response of such materials?
- …?

Required background of the student: Physico-Chemistry

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Van Der Linden, M. N., Alexander, L. C., Aarts, D. G., & Dauchot, O. (2019). Interrupted motility induced phase separation in aligning active colloids. PRL 123(9), 098001.
2. Bricard, A., Caussin, J. B., Desreumaux, N., Dauchot, O., & Bartolo, D. (2013). Emergence of macroscopic directed motion in populations of motile colloids. Nature, 503(7474), 95-98.
3. Izri, Z., Van Der Linden, M. N., Michelin, S., & Dauchot, O. (2014). Self-propulsion of pure water droplets by spontaneous Marangoni-stress-driven motion. PRL, 113(24), 248302.
4. Baconnier, P., Shohat, D., López, C.H. et al. Selective and collective actuation in active solids. Nat. Phys. (2022). https://doi.org/10.1038/s41567-022-01704-x
5. Briand, G., Schindler, M., & Dauchot, O. (2018). Spontaneously flowing crystal of self-propelled particles. PRL, 120(20), 208001

Illustrations :



TITLE: STUDY OF THE MICROSTRUCTURE, MECHANICAL AND FATIGUE PROPERTIES OF TI-6AL-4V AND AL-CO-CR-FE-NI HIGH ENTROPY ALLOYS COMPONENTS FABRICATED BY WIRE-ARC ADDITIVE MANUFACTURING

Topic number : ***2022_017***

Field : Material science, Mechanics and Fluids, Energy, Processes,

Subfield:

ParisTech School: Arts et Métiers
Research team: MMS - Mechanics, Materials and Surfaces msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Barrallier Laurent Laurent.Barrallier@ensam.eu
Advisor 2: Slim Mohamed Fares mohamed-fares.slim@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Wire-arc additive manufacturing (WAAM) is an additive manufacturing process that allows to print large-scale and complex geometry components with a high deposition rate and low manufacturing cost. Titanium alloys, especially Ti-6Al-4V, and High Entropy Alloys (HEA), Al-Co-Cr-Fe-Ni, are of high interest due to their attractive mechanical and physical properties. They are good candidates for aviation and aerospace industry and many other fields. Recently, their manufacturing feasibility by WAAM was demonstrated. Nevertheless, their microstructure, mechanical and fatigue properties are not yet under control and need more attention in order to be understood and optimized. Residual stresses, crystallographic and morphologic texture and metallurgical defects such as porosity, lack of fusion, microstructure coarsening and chemical segregation at the grain boundary are often present in WAAMed components.
The purpose of this work is to characterize the properties of HEA Al-Co-Cr-Fe-Ni alloy and Ti-6Al-4v parts fabricated by WAAM and asses the relationship between the obtained microstructure and the mechanical and fatigue properties. A link to the process parameters will be also

established. The microstructure and texture will be investigated using microscopic observation, Electron Backscatter Diffraction (EBSD) and X-ray diffraction. To reveal the pores and internal defects, X-ray tomography will be performed using synchrotron X-rays. The residual stresses will be investigated at different scales using laboratory X-ray diffraction, synchrotron or neutron diffraction and High-Resolution EBSD. The chemistry of the deposited layers will be characterized using Energy Dispersive Spectroscopy (EDS). The mechanical and fatigue properties of the fabricated components will be assessed using instrumented fatigue and tensile tests. Some post-processing treatment such as shot peening and heat treatment will be investigated and their effect on the properties of the WAAMed material will be characterized.

Required background of the student: Materials Science and/or Mechanical Engineering. An experience with diffraction using neutrons or synchrotron radiation is highly appreciated.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. 1. M. F. Slim, G. Guillaume, F. Rouillard, B. Malard, Determination of residual stress gradient in a Ti-stabilized austenitic stainless steel cladding candidate after carburization in liquid sodium at 500°C and 600°C, Acta Materialia, 221, 117435 (2021).
2. 2. M. F. Slim, G. Geandier, B. Malard, F. Rouillard, Microstructural and chemical changes of a Ti-stabilized austenitic stainless steel after exposure to liquid sodium at temperatures between 500°C and 650°C, Metallurgical and Materials Transactions A, 52, 4438 – 4453 (2021).
3. 3. M. F. Slim, A. Alhussein, E. Zgheib, M. François, Determination of single-crystal elasticity constants of beta phase in a multiphase tungsten thin film using impulse excitation technique, X-ray diffraction and micro-mechanical modeling, Acta Materialia, 175, 348 – 360 (2019).
4. 4. J.-P. Goulmy, S. Jégou, and L. Barrallier. Towards an image quality criterion to optimize digital image correlation. use of an analytical model to optimize acquisition conditions. Optics and Laser Technology, 148(107792):1-11, (2022).
5. 5. H. Weil, L. Barrallier, S. Jégou, N. Caldeira-Meulnotteand, and G. Beck. Optimization of gaseous nitriding of carbon iron-based alloy based on fatigue resistance modelling. International Journal of Fatigue, 110:238-245, (2018)

Illustrations :

TITLE: OPTIMIZATION OF AN OVERSPRAY SYSTEM FOR TURBOMACHINES APPLICATIONS

Topic number : ***2022_018***

Field : Energy, Processes, ,

Subfield: turbomachinery

ParisTech School: Arts et Métiers
Research team:
Research lab: LIFSE - Laboratoire Ingénierie des Fluides Systèmes Energétiques
Lab location: Paris
Lab website:https://lifse.artsetmetiers.fr

Contact point for this topic: Arts et Métiers

Advisor 1: Sofiane Khelladi sofiane.khelladi@ensam.eu
Advisor 2: Tommaso Capurso tommaso.capurso@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Pressurized air is used in different fields of application where its thermodynamic properties should match the specific user requests. Unfortunately, the air final compression temperature is inherently affected by friction losses and fluid dynamic irreversibilities. Not only that, the system operating condition is also altered by the external ambient conditions (pressure and temperature), thus different air cooling systems have been proposed in the literature with the purpose to control the final temperature of compressed air.
In this project, the overspray water injection is proposed as a valuable solution to control the compression temperature in order to achieve an efficient wet compression. Exploiting the water evaporation during compression, the process tends to follow an isothermal transformation, which is more efficient and allows to gain compression work. Unfortunately, this alters the compression system stability.
From the designer point of view, the evaporation is usually treated as in thermodynamic equilibrium, hence neglecting the entropy variation associated to evaporation, therefore overestimating the final efficiency. On the top of that, the effectiveness of the entire process is a multi-objective problem affected by the spray quantity and pattern, pressure

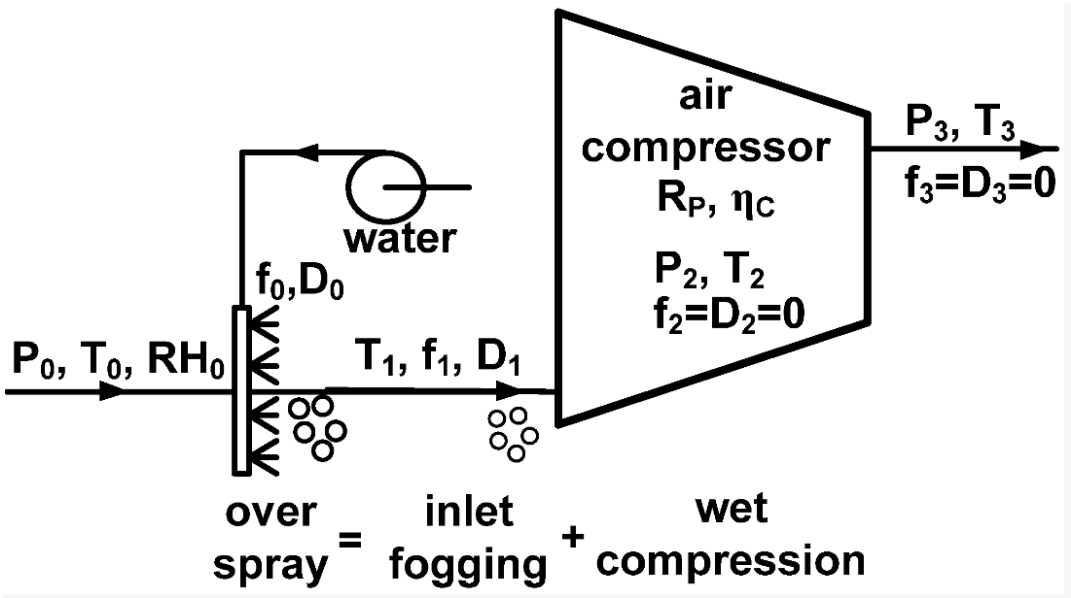
drop, and droplets diameter.
Finally, this project aims at proposing an innovative wet compression that works efficiently in both design and off-design conditions by applying a design optimization and carrying out advances computational fluid dynamic simulations of the system.

Required background of the student: Fluid machinery, Computational fluid dynamics, thermodynamics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. 1. Bergamini, L., Torresi, M., Capurso, T. (07-05-2018). IT201600111763 (A1) - HIGH EFFICIENCY DOUBLE SUCTION IMPELLER. https://patents.google.com/patent/US20210190073A1/en
2. 2. Capurso, T., Bergamini, L., Torresi, M. (2019). Design and CFD performance analysis of a novel impeller for double suction centrifugal pumps. Journal of Nuclear Engineering and Design. Vol. 341 Pages 155-166 Elsevier. https://doi.org/ 10.1016/j.nucengdes.2018.11.002.
3. 3. P. Tomov, L. Pora, R. Paridaens, T. Magne, M. Kebdani, S. Khelladi, F. Bakir, "Study of the Hydraulic Performances of Two Inducers in Water —CO2 Mixture—Toward Performance Improvement With Suppression of Prerotation." ASME. J. Fluids Eng., 144(4): 041203., 2022
4. 4. F. Ravelet, A. Danlos, F. Bakir, K. Croci, S. Khelladi, Ch. Sarraf, "Development of Attached Cavitation at Very Low Reynolds Numbers from Partial to Super-Cavitation", Applied Science, 10(20), 7350; 2020
5. 5. Capurso, T., Lorusso, M., Camporeale, S.M., Fortunato, B., Torresi, M. (2018) Implementation of a passive control system for limiting cavitation around hydrofoils. IOP Conf. Ser.: Earth Environ. Sci. 240 032025. https://doi.org/10.1088/1755-1315/240/3/032025

Illustrations :


air
compressor
R_P, η_C
P_2, T_2
$f_2=D_2=0$
P_3, T_3
$f_3=D_3=0$
water
f_0,D_0
P_0, T_0, RH_0
T_1, f_1, D_1
over spray = inlet fogging + wet compression

TITLE: DEVELOPING SERIOUS GAMES FOR TEACHING INTERACTIVE PRODUCT DESIGN

Topic number : ***2022_019***

Field : Design, Industrialization, ,

Subfield: Innovation, Design Science, Serious Game, Interactive Product, Connected Product, IOT

ParisTech School: Arts et Métiers
Research team:
Research lab: LCPI - Laboratoire conception de produits et innovation
Lab location: Paris
Lab website:https://lcpi.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: JEAN Camille camille.jean@ensam.eu
Advisor 2: Ruding Lou Ruding.Lou@ensam.eu
Advisor 3: SEGONDS Frédéric frederic.segonds@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Design and innovation are necessary for companies to succeed in a globalized and competitive world. With the rapid development of digital technologies, forecasts on product development predict that interactive products will keep on growing fast (ISAKSSON et al., 2020; BRIARD et al., 2021). They are based on connected products and IOT technology. One of the key issues for companies lies in employing engineers and designers that understand the full technique of design and innovation of those product as well as continuously train those already hired.
Serious games are one solution to develop skills and teach product design in a ludic way (MA et al., 2019). Their usage is frequent as they can improve enjoyment, passionate involvement, structure, and social interaction while the learning takes place.
However, very few serious games tackle the subject of interactive product design.
This thesis aims at proposing a method to develop serious games for teaching interactive product design.
Application of this method will lead to the creation of one or more physical or digital serious games for teaching interactive product design.
The last technologies of Virtual and Augmented Reality could be used (LI

et al., 2018; PHAM VAN et al., 2022). The learning competences of the serious games created have to integrate the themes of product design, data collection, sensors integration and user experience. A robust evaluation of the serious games created will have to be carried out to validate the principles, heuristics and recommendations formulated.

Required background of the student: Curious, creative, and autonomous, you are passionate about innovation. You have an engineer profile in design / digital engineering and are willing to develop new skills in design sciences for the industry. Ideally, the candidate will have knowledge in the new technologies of Virtual and Augmented Reality

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. BRIARD, T., JEAN, C., AOUSSAT, A., VERON, P., LE CARDINAL, J. & WARTZACK, S. (2021). Data-driven design challenges in the early stages of the product development process. Proceedings of the Design Society, 1, 851-860. https://doi:10.1017/pds.2021.85
2. LI, B., SEGONDS, F., MATEEV, C., LOU, R., MERIENNE, F. (2018). Design in context of use: An experiment with a multi-view and multi-representation system for collaborative design, Computers in Industry, 103: 28 - 37, 2018. https://doi.org/10.1016/j.compind.2018.09.006
3. MA, Y., VALLET, F., CLUZEL, F., & YANNOU, B. (2019). Analyzing the Relevance of Serious Game Elements for Effectively Teaching Innovation Processes. Proceedings of the Design Society: International Conference on Engineering Design, 1(1), 439-448. https://doi:10.1017/dsi.2019.47
4. PHAM VAN, L., JEAN, C., MEYRUEIS, V., GAZO, C., MANTELET, F., GUEGUAN, J., BUISINE, S. & SEGONDS, F. 2022 IdeAM Running Quiz: A Digital Learning Game to Enhance Additive Manufacturing Opportunities Discovery. International Journal of Emerging Technologies in Learning (iJET), 17(10), pp. 32–50. https://doi.org/10.3991/ijet.v17i10.25695
5. ISAKSSON, O., ECKERT, C., (2020). Product Development 2040. The Design Society.
https://doi.org/10.35199/report.pd2040

Illustrations :


Arts et Métiers
Institute of Technology

ParisTech CSC PhD program - 2022-2023

Developing serious games for teaching interactive product design

Keywords: Innovation, Design Science, Serious Game, Interactive Product, Connected Product, IOT

Design and innovation are necessary for companies to succeed in a globalized and competitive world. With the rapid development of digital technologies, forecasts on product development predict that **interactive products** will keep on growing fast (ISAKSSON et al., 2020; BRIARD et al., 2021). They are based on **connected products and IOT technology**. One of the key issues for companies lies in employing engineers and designers that understand the full technique of design and innovation of those product as well as continuously train those already hired.

Serious games are one solution to develop skills and teach product design in a ludic way (MA et al., 2019). Their usage is frequent as they can improve enjoyment, passionate involvement, structure, and social interaction while the learning takes place.

However, very few serious games tackle the subject of interactive product design.

This thesis aims at **proposing a method to develop serious games for teaching interactive product design.**

Application of this method will lead to the creation of one or more physical or digital serious games for teaching interactive product design. The last technologies of Virtual and Augmented Reality could be used (LI et al., 2018; PHAM VAN et al., 2022). The learning competences of the serious games created have to integrate the themes of product design, data collection, sensors integration and user experience. A robust evaluation of the serious games created will have to be carried out to validate the principles, heuristics and recommendations formulated.

The research will be divided into three main phases:

- **State of the art**: The first year will be devoted to the development of a state of the art on the existing methodologies for the design of interactive product and serious games. Following this work, specifications will be formulated, and hypotheses of resolutions proposed. At the end of this first year, a detailed schedule of experiments will be defined
- **Proposal of a tooled methodology and experiments:** The second and third year will be devoted to experiments. The objective is to test, but above all to strengthen and validate the proposals. The methodology, tools and recommendations will be perfected by iteration, as experiments and conclusions can be drawn.
- **Formalization of research advances**: The last year will aim to synthesize all the work carried out to get an optimal proposition adapted to the context of the thesis.

References:

- BRIARD, T., JEAN, C., AOUSSAT, A., VERON, P., LE CARDINAL, J. & WARTZACK, S. (2021). Data-driven design challenges in the early stages of the product development process. *Proceedings of the Design Society*, *1*, 851-860. https://doi:10.1017/pds.2021.85
- LI, B., SEGONDS, F., MATEEV, C., LOU, R., MERIENNE, F. (2018). Design in context of use: An experiment with a multi-view and multi-representation system for collaborative design, Computers in Industry, 103: 28 - 37, 2018. https://doi.org/10.1016/j.compind.2018.09.006
- MA, Y., VALLET, F., CLUZEL, F., & YANNOU, B. (2019). Analyzing the Relevance of Serious Game Elements for Effectively Teaching Innovation Processes. *Proceedings of the Design Society: International Conference on Engineering Design, 1*(1), 439-448. https://doi:10.1017/dsi.2019.47
- PHAM VAN, L., JEAN, C., MEYRUEIS, V., GAZO, C., MANTELET, F., GUEGUAN, J., BUISINE, S. & SEGONDS, F. 2022 IdeAM Running Quiz: A Digital Learning Game to Enhance Additive Manufacturing Opportunities Discovery. *International Journal of Emerging Technologies in Learning (iJET),* 17(10), pp. 32–50. https://doi.org/10.3991/ijet.v17i10.25695
- ISAKSSON, O., ECKERT, C., (2020). Product Development 2040. The Design Society. https://doi.org/10.35199/report.pd2040

Contact : Camille JEAN - Camille.jean@ensam.eu

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: MULTISCALE SIMULATION OF PLASTIC STRAIN LOCALIZATION IN HIGH ENTROPY ALLOYS

Topic number : ***2022_020***

Field : Material science, Mechanics and Fluids, ,

Subfield: Mechanics

ParisTech School: Arts et Métiers
Research team: MMS
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Depriester Dorian dorian.depriester@ensam.eu
Advisor 2: Barrallier Laurent laurent.barrallier@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: High Entropy Alloys (HEAs) refer to metallic solutions made of at least five elements in equi- or near equi- atomic proportions. They usually have a simple crystallographic structure (face-centred cubic or centred cubic), and have remarkable mechanical properties, such as very high fracture toughness and large tensile strengths.

The fatigue resistance of alloys highly depends on their plastic behavior, hence the need for understanding the plastic activity in metals. As the computational capability of modern computers increases, the Crystal Plasticity Finite Element Method (CPFEM) becomes more and more popular in materials science to model the mechanical behavior of polycrystals. Indeed, such analysis provides extensive information about local mechanical fields (such as plastic strain and stress).

When a polycrystal undergoes plastic strain, localization usually occurs because of heterogeneities and local anisotropies inherent to the crystallites. This phenomenon can be evidenced by performing an in situ tensile test in the chamber of a Scanning Electron Microscope (SEM) coupled with Digital Image Correlation (DIC) made from SEM images.

Plastic localization actually occurs at two scales, namely mesoscopic and microscopic. Indeed, in one hand, localization bands can be seen at mesoscopic scale, passing through the entire sample thickness; their orientations are usually related to the loading direction and their thickness is typically of the same order of magnitude as the grain size (usually >1 µm) . On the other hand, intragranular banding also occurs at microscopic scale; these bands appear evenly spaced in each grain, with thickness of a few hundred nanometres. Their orientations mainly depend on the crystallographic orientation of the grain.

To the best proposer's knowledge, there is no model available in the literature able to simulate the formation of both mesoscopic and microscopic localization bands at once. Starting from in situ tensile tests and DIC performed on HEAs, a localization criterion will be set up. This criterion will be implemented into a CPFEM code, taking advantage of prior works made by the MSMP laboratory about micromechanics.

Required background of the student: Continuum mechanics, Finite Element Method, Materials science, Microscopy (SEM and EBSD techniques)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. J.P. Goulmy and D. Depriester and F. Guittonneau and L. Barrallier and S. Jégou (2022), Mechanical behavior of polycrystals: Coupled in situ DIC-EBSD analysis of pure copper under tensile test, Materials Characterization, doi.org/10.1016/j.matchar.2022.112322.

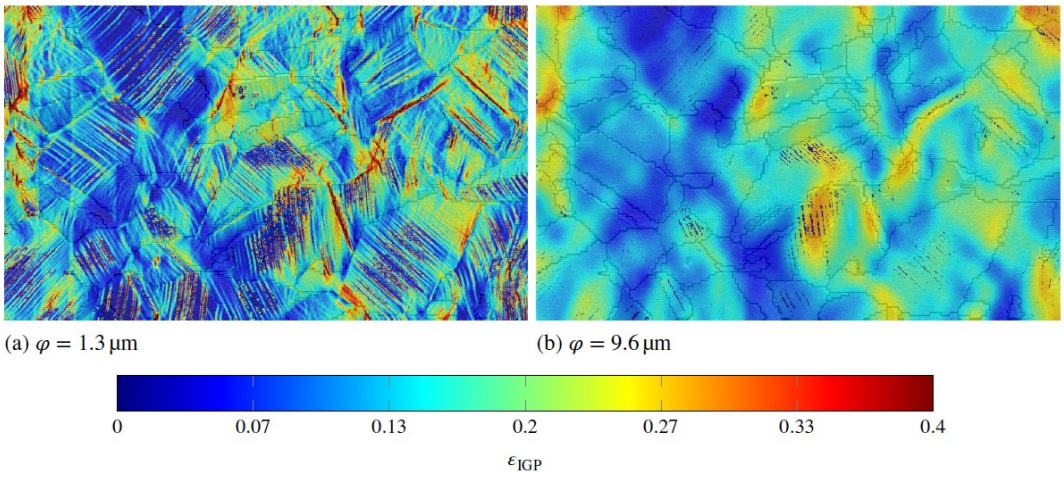
2. D. Depriester and R. Kubler, MTEX2Gmsh (2020): a tool for generating 2D meshes from EBSD data, Journal of Open Source Software, doi.org/10.21105/joss.02094

3. J. Ledieu and M. Feuerbacher and C. Thomas and M.-C. de Weerd and S. Šturm and M. Podlogar and J. Ghanbaja and S. Migot and M. Sicot and V. Fournée (2021), The (110) and (320) surfaces of a Cantor alloy, Acta Materialia, doi.org/10.1016/j.actamat.2021.116790.

4. M. Yaghoobi and S. G. and S. Sundar and A. Lakshmanan and S. Rudraraju and J. E. Allison and V. Sundararaghavan (2019), PRISMS-Plasticity: An open-source crystal plasticity finite element software, Computational Materials Science, doi.org/10.1016/j.commatsci.2019.109078

5.

Illustrations :



(a) $\varphi = 1.3\,\mu m$ (b) $\varphi = 9.6\,\mu m$

TITLE: DATA-DRIVEN ADAPTIVE STATISTICAL PROCESS CONTROL FOR SMART MANUFACTURING

Topic number : ***2022_021***

Field : Design, Industrialization, Mathematics and their applications, Energy, Processes

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: DANTAN Jean-Yves jean-yves.dantan@ensam.eu
Advisor 2: HOMRI Lazhar lazhar.homri@ensam.eu
Advisor 3: ZOUHRI Wahb wahb.zouhri@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: With the emergence of industry 4.0 and data-driven approaches usage within smart manufacturing systems, statistical process control (SPC) should be adapted by considering feedbacks and knowledge from users and process, in order to improve the product development, to ensure its quality and reliability and to identify process drifts or anomalies. The provided information from the process is generally represented as time series data or signals. Dynamic process control constantly drives process improvement by focusing on extracting knowledge from gathered data for immediate actions, ensuring therefore more efficiency and schedule adherence. It could automatically analyse the process and send alerts for immediate assessment. By continually leading improvements, systems performance and quality are thus maximized. In fact, undefined anomalies usually result into a breakdown of the equipment or a fault in the working of the equipment. Therefore, adopting a new anomaly detection approach for process control will lead to test's cost reduction and allow a quick identification of anomalies and unexpected patterns.

Moreover, the derived knowledge can be used to improve the product

design specifications and defining its verification and validation plans to build functional and reliable models.

Required background of the student: Statistics, Computer Science, Mechanical Engineering, Industrial Engineering.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Zouhri, W., Dantan, J. Y., Häfner, B., Eschner, N., Homri, L., Lanza, G., Theile, O. & Schäfer, M. (2020). Optical process monitoring for Laser-Powder Bed Fusion (L-PBF). CIRP Journal of Manufacturing Science and Technology, 31, 607-617
2. Ciancio V., Homri L., Dantan J.-Y., Siadat A., 2020. Towards prediction of machine failures: overview and first attempt on specific automotive industry application. IFAC-PapersOnLine 53, 289-294. 2020.
3. Bassetto S., Siadat A., Martin P., Adavanced Process Control Application Modelling. CIRP Intelligent Computation Manufacturing Engineering, Jul 2002, ischia, Italy
4. Himeur Y., Ghanem K., Alsalemi A., Bensaali F., Artificial intelligence-based anomaly detection of energy consumption in buildings: A review, current trends and new perspectives, Applied Energy 287, 2021.
5. Zouhri, W., Homri, L., & Dantan, J. Y. (2020). Handling the impact of feature uncertainties on SVM: A robust approach based on Sobol sensitivity analysis. Expert Systems with Applications, 2021

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: OPTIMIZED SET-UP TO CHARACTERIZE THE CONTACT FATIGUE DAMAGE OF MATERIAL WITH GRADIENT PROPERTIES

Topic number : ***2022_022***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: Mechanics, Materials and Surfaces
https://www.msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Goulmy Jean-Patrick jean-patrick.goulmy@ensam.eu
Advisor 2: Barrallier Laurent Laurent.Barrallier@ensam.eu
Advisor 3:
Advisor 4:

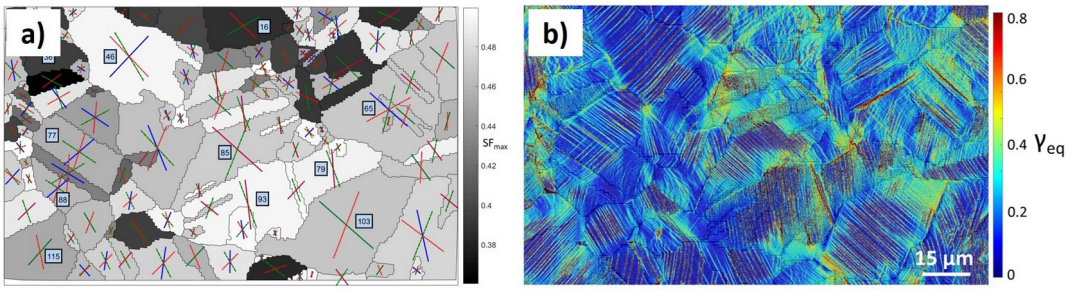
Short description of possible research topics for a PhD: Surface treatments (coating, shot peening, sandblasting, nitriding) aim to modify the properties (chemical, mechanical, ...) on the surface or subsurface of a part to improve its initial characteristics by creating a microstructure gradient associated with a residual mechanical field . This type of process is used in many industrial fields (aeronautics, automotive, ...), on very diverse critical parts (turbine disks, gears, connecting rods...) . A fine characterization of the impact of surface treatments on the improvement of part performance is paramount for safety issues, optimization of their shape and process parameters. This project aims to contribute to the understanding of damage mechanisms observed during contact fatigue. It will develop new experiments to characterize the integrity of surfaces with gradients in properties during repeated cycles between a sphere and the part. Damage monitoring will be performed using different characterization techniques (DIC, SEM, EBSD, XRD) . Particular attention will be paid to define a representative volume of macroscopic damage with the different characterization techniques used. To the experimental tests, a modeling of the test will be coupled to better understand the mechanisms at the origin of the damage of the studied parts.

Required background of the student: • Candidates should have a master of degree in materials science or mechanical engineering
• Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Fabre, A., H.P. Evans, L. Barrallier, K.J. Sharif, and M. Desvignes. 2013. “Prediction of Microgeometrical Influences on Micropitting Fatigue Damage on 32CrMoV13 Steel.” Tribology International 59 (March): 129–40. https://doi.org/10.1016/j.triboint.2012.07.018.
2. Kubler, R.F., R. Rotinat, J. Badreddine, and Q. Puydt. 2020. “Experimental Analysis of the Shot Peening Particle Stream Using Particle Tracking and Digital Image Correlation Techniques.” Experimental Mechanics, January. https://doi.org/10.1007/s11340-019-00574-4.
3. Goulmy, J.P., 2017. “Modélisation de l’impact Du Grenaillage Sur Le Comportement et de l’endommagement En Fatigue de l’Inconel 718.” Troyes: Université de Technologie de Troyes.
4. Goulmy, J.P., S. Jégou, and L. Barrallier. 2022. “Towards an Image Quality Criterion to Optimize Digital Image Correlation. Use of an Analytical Model to Optimize Acquisition Conditions.” Optics & Laser Technology 148 (April): 107792. https://doi.org/10.1016/j.optlastec.2021.107792.
5. Goulmy, J.P., D. Depriester, F. Guittonneau, L. Barrallier, S. Jégou. 2022. “Mechanical behavior of polycrystals: Coupled in situ DIC-EBSD analysis of pure copper under tensile test.” Materials Characterization, 112322, https://doi.org/10.1016/j.matchar.2022.112322.

Illustrations :



Examples of coupling of characterization techniques to characterize material behavior.
a) EBSD measurements, b) strain field from HRDIC measurements [5]

TITLE: A SMART MANUFACTURING PROJECT: DIGITAL IMAGE CORRELATION CHARACTERIZATION OF RESIDUAL STRESSES INDUCED DURING THE SHOT PEENING PROCESS

Topic number : ***2022_023***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: Mechanics, Materials and Surfaces
https://www.msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Goulmy Jean-Patrick jean-patrick.goulmy@ensam.eu
Advisor 2: Barrallier Laurent Laurent.Barrallier@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: This project is part of a smart manufacturing approach aimed at optimizing shot peening processes in real time. The development of new characterization tools and the increase of data processing capacities in a reduced time allow increasing the machines' ability to modify the parameters during the manufacturing of the parts. Real-time knowledge of residual stresses induced by the shot peening process represents a major challenge for manufacturers. It could be used to optimize manufacturing processes and thus increase the performance of parts in a minimum amount of time. To answer this problem, the Digital Image Correlation (DIC) technique will be used. This method of characterization is currently in full development . It allows visualization of the displacement and strain fields induced during a solicitation. From the measurements made on the surface of the part and by coupling these data to the modeling of the process, it will be possible to determine the residual stress field induced in the depth . In addition, other experimental analyzes could be performed to complete the measurements (microhardness, XRD, ...) . Artificial intelligence tools can

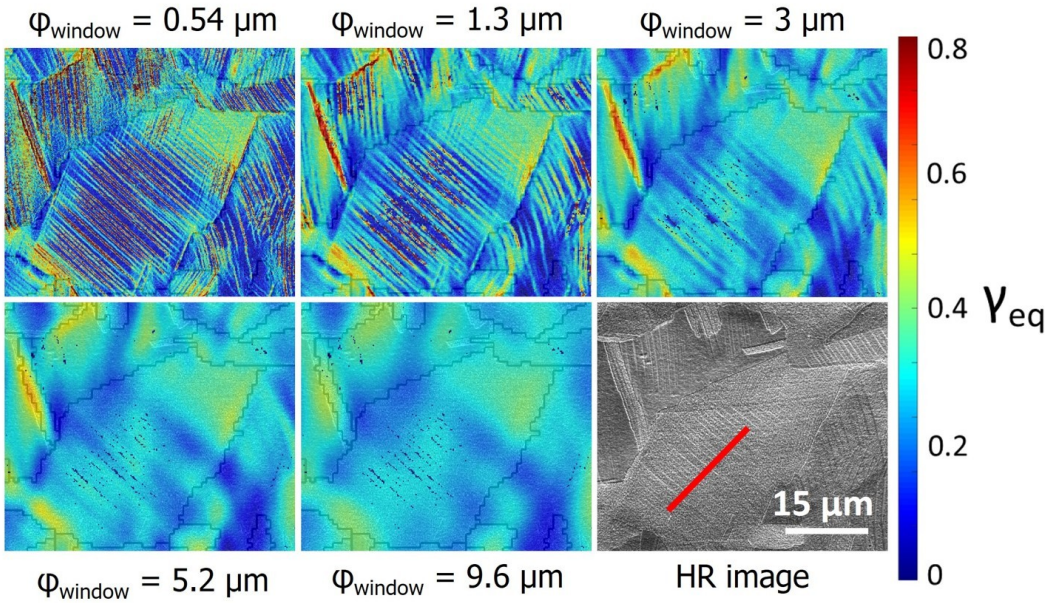
also be used to address the problem . This work will also contribute to the development of a digital platform to link experimentation and modeling.

Required background of the student: • Candidates should have a master of degree in materials science or mechanical engineering
• Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)
• Knowledge of process influence on residual stress would be a plus

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Goulmy, J.P., S. Jégou, and L. Barrallier. 2022. “Towards an Image Quality Criterion to Optimize Digital Image Correlation. Use of an Analytical Model to Optimize Acquisition Conditions.” Optics & Laser Technology 148 (April): 107792. https://doi.org/10.1016/j.optlastec.2021.107792.
2. Goulmy, J.P., D. Depriester, F. Guittonneau, L. Barrallier, S. Jégou. 2022. “Mechanical behavior of polycrystals: Coupled in situ DIC-EBSD analysis of pure copper under tensile test.” Materials Characterization, 112322, https://doi.org/10.1016/j.matchar.2022.112322.
3. Kubler, R. F., S. Berveiller, D. Bouscaud, R. Guiheux, E. Patoor, and Q. Puydt. 2019. “Shot Peening of TRIP780 Steel: Experimental Analysis and Numerical Simulation.” Journal of Materials Processing Technology 270 (August): 182–94. https://doi.org/10.1016/j.jmatprotec.2019.02.031.
4. Goulmy, J. P., P. Kanoute, E. Rouhaud, L. Toualbi, S. Kruch, V. Boyer, J. Badreddine, and D. Retraint. 2021. “A Calibration Procedure for the Assessment of Work Hardening Part II: Application to Shot Peened IN718 Parts.” Materials Characterization 175 (May): 111068. https://doi.org/10.1016/j.matchar.2021.111068.
5. Kubler, R.F., R. Rotinat, J. Badreddine, and Q. Puydt. 2020. “Experimental Analysis of the Shot Peening Particle Stream Using Particle Tracking and Digital Image Correlation Techniques.” Experimental Mechanics, January. https://doi.org/10.1007/s11340-019-00574-4.

Illustrations :



Example of the influence of spatial resolution on the results of digital image correlation [2].

TITLE: CHARACTERIZATION OF THE EVOLUTION OF MECHANICAL PROPERTIES OF MATERIALS DURING IN-SITU SEM TESTS IN TEMPERATURE: IMPLEMENTATION OF THE HRDIC TECHNIQUE

Topic number : ***2022_024***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: Mechanics, Materials and Surfaces
https://www.msmp.eu/equipes/mms/
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location: Aix-en-Provence
Lab website:https://www.msmp.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Goulmy Jean-Patrick jean-patrick.goulmy@ensam.eu
Advisor 2: Barrallier Laurent Laurent.Barrallier@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Many mechanical parts are sensitive to temperature (turbine disks, connecting rods...). It is therefore essential to know the behavior of materials at these temperatures. Recent developments have made it possible to increase the spatial resolution during the study of mechanical fields, through the implementation of the high-resolution image correlation (HRDIC) technique . This technique is in full development and many challenges must still be met to have reliable measurements, especially at high temperatures. The objective is to develop methods of in-situ characterization by scanning electron microscope to identify the evolution of mechanical fields during thermal loading. A methodology based on the study of materials with very different characteristics (presence of residual stresses, inclusion of particles with different thermal extension coefficients, ...) will be developed. It should allow the creation of measurement and analysis protocols to identify the mechanical behavior of materials under thermal loading. For this, the technique of HRDIC will be used and could be coupled with electron backscattered diffraction measurements. Thanks to these measurements,

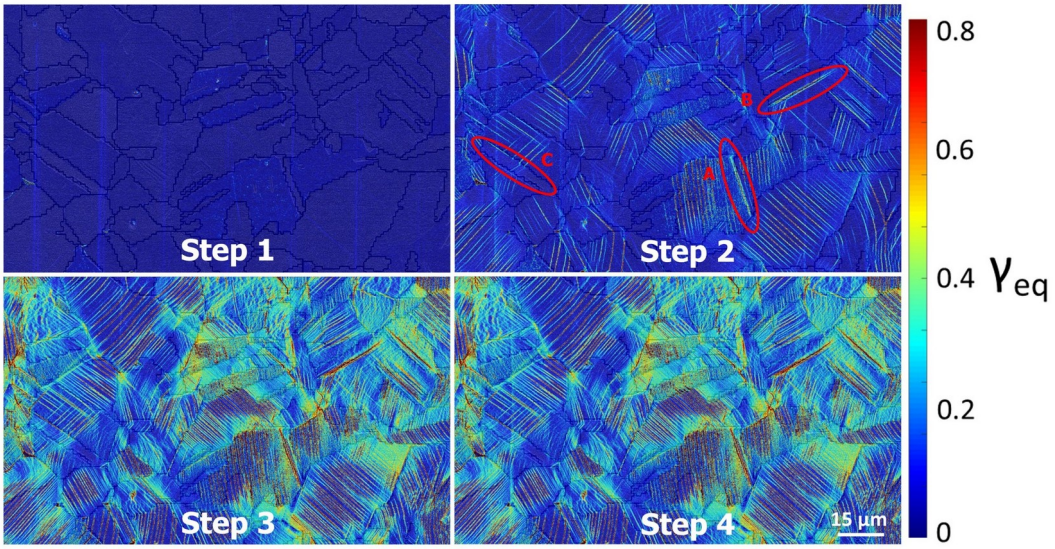
this work will contribute to the development of a digital platform to link experimentation and modeling. It will consist of developing tools to link the mechanical properties at the grain scale with polycrystalline models .

Required background of the student: • Candidates should have a master of degree in materials science or mechanical engineering
• Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Goulmy, J.P., S. Jégou, and L. Barrallier. 2022. “Towards an Image Quality Criterion to Optimize Digital Image Correlation. Use of an Analytical Model to Optimize Acquisition Conditions.” Optics & Laser Technology 148 (April): 107792. https://doi.org/10.1016/j.optlastec.2021.107792.
2. Goulmy, J.P., D. Depriester, F. Guittonneau, L. Barrallier, S. Jégou. 2022. “Mechanical behavior of polycrystals: Coupled in situ DIC-EBSD analysis of pure copper under tensile test.” Materials Characterization, 112322, https://doi.org/10.1016/j.matchar.2022.112322.
3. Depriester, D., and R. Kubler. 2021. “Grain Size Estimation in Polycrystals: Solving the Corpuscle Problem Using Maximum Likelihood Estimation.” Journal of Structural Geology 151 (October): 104418. https://doi.org/10.1016/j.jsg.2021.104418.
4.
5.

Illustrations :



Example of HRDIC observations on pure copper for different tensile loads [2]

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: STUDY OF THE LOW FREQUENCY DYNAMICS OF COMPRESSIBLE SEPARATIONS

Topic number : ***2022_025***

Field : Material science, Mechanics and Fluids, Mathematics and their applications,

Subfield: Compressible aerodynamics, dynamical systems

ParisTech School: Arts et Métiers
Research team:
Research lab: DynFluid
Lab location: Paris
Lab website:http://dynfluid.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: ROBINET Jean-Christophe Jean-christophe.ROBINET@ensam.eu
Advisor 2: BEN HASSAN SAÏDI Ismaïl ismail.benhassansaidi@ensam.eu
Advisor 3: TENAUD Christian christian.tenaud@centralesupelec.fr
Advisor 4:

Short description of possible research topics for a PhD: Situations in which a shock wave interacts with a boundary layer (SWBLI: Shock Wave Boundary Layer Interaction) are numerous in the aeronautical and spatial industries. These interactions can exist on external surfaces (transonic profiles, junctions of surfaces, etc.) or on in internal aerodynamics (supersonic air intakes, cascade of turbine blades, nozzles, etc.). Under certain circumstances (High Mach number, large shock angle...), these interactions between an incident shockwave and a boundary layer may create an unsteady separation bubble (compressible separation). The separation leads to an increase in the drag force, the heat fluxes, and the pressure fluctuations at the wall. Moreover, numerous previous studies have shown that the separation bubble as well as the reflected shock wave are submitted to a low-frequency streamwise motion known as the SWBLI unsteadiness. This phenomenon subjects structures to oscillating loads that can lead to damage to the solid structural integrity. It is well documented; however, controversy remains concerning the physical mechanism at the origin of this low-frequency unsteadiness. Some mechanisms put forward the fact that the unsteadiness would be due to the excitation of the interaction zone by the

structures of the turbulent boundary layer. Other hypotheses link this phenomenon to the intrinsic dynamics of the recirculation bubble.

The team of researchers who proposes the Ph.D. thesis subject has acquired over the years solid expertise in high-fidelity numerical simulation and analysis of the dynamics of SWBLIs and in particular its low-frequency dynamics. The team has at its disposal DNS/LES computational codes developed in the laboratory which have already allowed to perform laminar, transitional, and turbulent SWBLI simulations. The physical analysis tools, whose codes are developed in-house, range from linear stability analysis (local or global) to modal decomposition (Proper Orthogonal Decomposition (POD), Spectral Proper Orthogonal Decomposition (SPOD), Dynamic Mode Decomposition (DMD), BiSpectal Mode Decomposition (BSMD)). All the research work carried out within the team has made it possible to highlight the preponderant role of the intrinsic dynamics of the recirculation bubble in the SWBLI unsteadiness and to refine the understanding of the mechanisms involved.

However, many questions remain open. The aim of this thesis is to address these issues. The objective is not the study of realistic industrial flows but of simplified canonical academic configurations from a physical understanding point of view. In particular, it is planned to focus on laminar and transitional flat-plate SWBLIs to remove the presumed influence of large-scale turbulent structures in the incident boundary layer on the SWBLI unsteadiness. In this context, the focus will be on the linear stability analysis of these flows. In parallel, the analysis of the nonlinear dynamics of the flow will be carried out, and the links between the linear stability and the nonlinear dynamics of the flow will be explored. These analyses should provide a clear picture of the physical mechanisms behind the SWBLI unsteadiness in the laminar case. The study can then be oriented towards increasing the complexity of the flow by considering forced transitional SWBLIs, in order to understand the influence of convective instabilities on the global dynamics of the flow. Finally, the turbulent case on a flat plate can be considered for comparison with the mechanisms involved in the laminar and transitional cases.

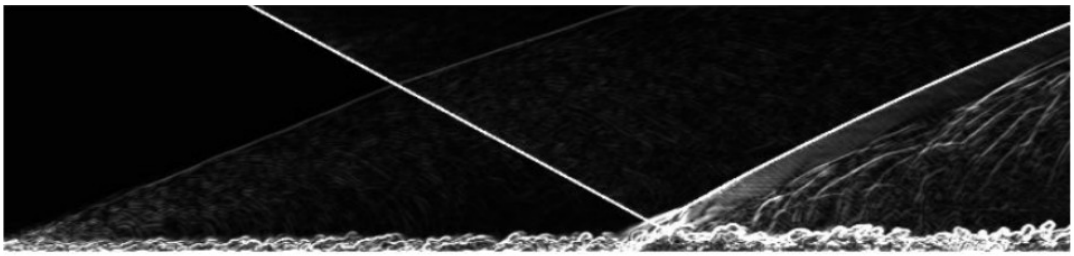
The understanding of the physical mechanisms at the origin of the low frequency unsteadiness of the SWBLI, which is the objective of this thesis, has for ultimate goal the possibility of controlling this phenomenon in order to improve the performances and to make more reliable the concerned industrial systems.

Required background of the student: The desired candidate has a research master's degree with a specialization in fluid mechanics or applied mathematics. The candidate must be interested in the physical analysis and understanding of flow dynamics. A good experience and a taste for analysis and numerical simulation tools are essential. An interest in supersonic aerodynamics is also desirable.

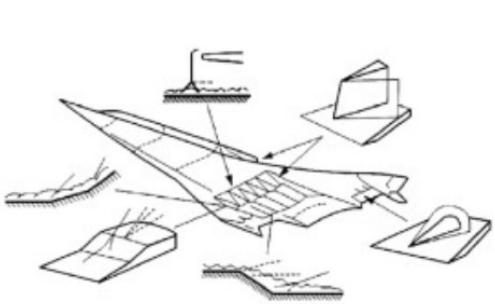
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. I. Ben Hassan Saïdi (2019), Numerical simulations of the shock wave-boundary layer interactions. PhD thesis. /
I. Ben Hassan Saïdi, C. Tenaud, and G. Fournier (2021), Role of the recirculation bubble dynamics on the unsteadiness of the Shock Wave Boundary Layer Interaction. 25th ICTAM Congress, Aug. 2021, Milano, Italy. /
I. Ben Hassan Saïdi, G.Fournier, and C. Tenaud (2021), Contribution of the breathing modes in the SWTBLI unsteadiness, 55th 3AF International Conference on Applied Aerodynamics, Poitiers, France
2. J.-Ch, Robinet (2007), Bifurcations in shock-wave/laminar-boundary-layer interaction: global instability approach, Journal of Fluid Mechanics, 579: 85-112. https://doi.org/10.1017/S0022112007005095
3. F. Guiho, F. Alizard and J.-Ch, Robinet (2016), Instabilities in oblique shock wave/laminar boundary-layer interactions, Journal of Fluid Mechanics, 789: 1-35. https://doi.org/10.1017/jfm.2015.729
4. G. Aubard, X. Gloerfelt and J.-Ch, Robinet (2013), Large-Eddy Simulation of Broadband Unsteadiness in a Shock/Boundary-Layer Interaction, AIAA Journal, 51: 2395-2409. https://doi.org/10.2514/1.J052249
5. B. Bugeat, J.-Ch. Robinet, J.-C. Chassaing and P. Sagaut (2022), Low-frequency resolvent analysis of the laminar oblique shock wave/boundary layer interaction, Journal of Fluid Mechanics, 942: A43. doi:10.1017/jfm.2022.390

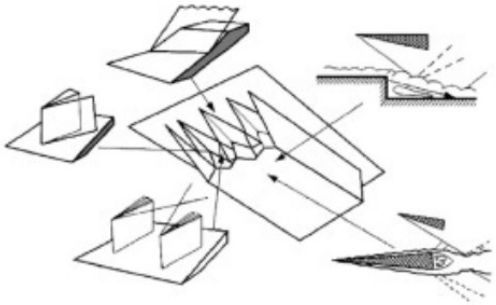
Illustrations :



Numerical Schlieren from Ben hassan Saïdi PhD. Thesis, 2019



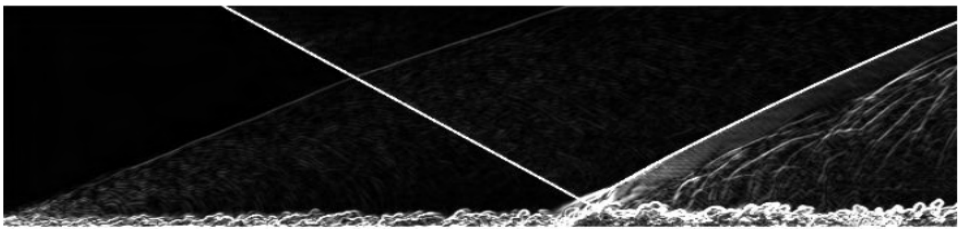
(a) Interactions in the vicinity of a high-speed vehicle



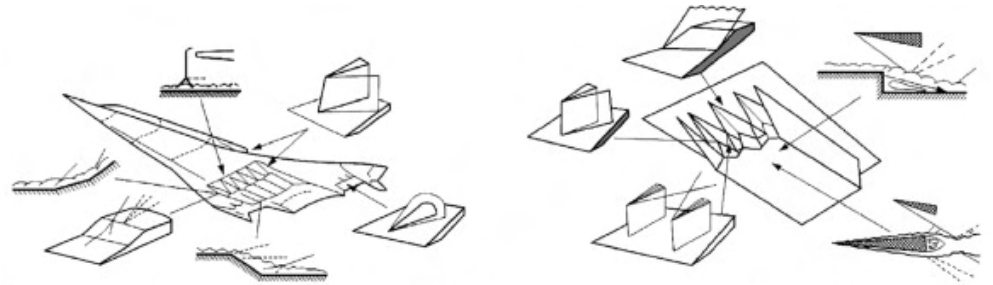
(b) Interactions in the vicinity of a scramjet

PhD. Thesis proposal

Study of the low frequency dynamics of compressible separations



Numerical Schlieren from Ben hassan Saïdi PhD. Thesis, 2019



Schemes from Wu et al., 2013, Review of shock wave detection method in CFD post-processing, Chinese Journal of Aeronautics

Subject: situations in which a shock wave interacts with a boundary layer (SWBLI: Shock Wave Boundary Layer Interaction) are numerous in the aeronautical and spatial industries. These interactions can exist on external surfaces (transonic profiles, junctions of surfaces, etc.) or on in internal aerodynamics (supersonic air intakes, cascade of turbine blades, nozzles, etc.). Under certain circumstances (High Mach number, large shock angle...), these interactions between an incident shockwave and a boundary layer may create an unsteady separation bubble (compressible separation). The separation leads to an increase in the drag force, the heat fluxes, and the pressure fluctuations at the wall. Moreover, numerous previous studies have shown that the separation bubble as well as the reflected shock wave are submitted to a low-frequency streamwise motion known as the SWBLI unsteadiness. This phenomenon subjects structures to oscillating loads that can lead to damage to the solid structural integrity. It is well documented; however, controversy remains concerning the physical mechanism at the origin of this low-frequency unsteadiness. Some mechanisms put forward the fact that the unsteadiness would be due to the excitation of the interaction zone by the structures of the turbulent boundary layer. Other hypotheses link this phenomenon to the intrinsic dynamics of the recirculation bubble.

The team of researchers who proposes the Ph.D. thesis subject has acquired over the years solid expertise in high-fidelity numerical simulation and analysis of the dynamics of SWBLIs and in particular its low-frequency dynamics. The team has at its disposal DNS/LES computational codes developed in the laboratory which have already allowed to perform laminar, transitional, and turbulent SWBLI simulations. The physical analysis tools, whose codes are developed in-house, range from linear stability analysis (local or global) to modal decomposition (Proper Orthogonal Decomposition (POD), Spectral Proper Orthogonal Decomposition (SPOD), Dynamic Mode Decomposition (DMD), BiSpectal Mode Decomposition (BSMD)). All the research work carried out within the team has made it possible to highlight the preponderant role of the intrinsic dynamics of the recirculation bubble in the SWBLI unsteadiness and to refine the understanding of the mechanisms involved.

However, many questions remain open. The aim of this thesis is to address these issues. **The objective is not the study of realistic industrial flows but of simplified canonical academic configurations from a physical understanding**

point of view. In particular, it is planned to focus on laminar and transitional flat-plate SWBLIs to remove the presumed influence of large-scale turbulent structures in the incident boundary layer on the SWBLI unsteadiness. In this context, the focus will be on the linear stability analysis of these flows. In parallel, the analysis of the nonlinear dynamics of the flow will be carried out, and the links between the linear stability and the nonlinear dynamics of the flow will be explored. These analyses should provide a clear picture of the physical mechanisms behind the SWBLI unsteadiness in the laminar case. The study can then be oriented towards increasing the complexity of the flow by considering forced transitional SWBLIs, in order to understand the influence of convective instabilities on the global dynamics of the flow. Finally, the turbulent case on a flat plate can be considered for comparison with the mechanisms involved in the laminar and transitional cases.

The understanding of the physical mechanisms at the origin of the low frequency SWBLI unsteadiness, which is the objective of this thesis, has for ultimate goal the possibility of controlling this phenomenon in order to improve the performances and to make more reliable the concerned industrial systems.

Location of the thesis: The candidate will be enrolled at the Ecole Nationale Supérieure de Arts et Métiers and will carry out his/her research at the DynFluid laboratory (http://dynfluid.ensam.eu/). This work will also be co-supervised by a researcher from EM2C laboratory (https://em2c.centralesupelec.fr/) located at CentraleSupelec engineering school.

Candidate profile: The desired candidate has a research master's degree with a specialization in fluid mechanics or applied mathematics. The candidate must be interested in the physical analysis and understanding of flow dynamics. A good experience and a taste for analysis and numerical simulation tools are essential. An interest in supersonic aerodynamics is also desirable.

Contact: For more information and to apply (CV and cover letter), please contact :

- Jean-Christophe ROBINET: jean-christophe.robinet@ensam.eu
- Ismaïl BEN HASSAN SAÏDI: Ismail.benhassansaidi@ensam.eu
- Christian TENAUD: Christian.tenaud@centralesupelec.fr

Bibliography:

1 I. Ben Hassan Saïdi (2019), *Numerical simulations of the shock wave-boundary layer interactions.* PhD thesis.

2 I. Ben Hassan Saïdi, G. Fournier & C. Tenaud (2020), *On the behavior of high order one-step monotonicity-preserving scheme for direct numerical simulation of turbulent flows.* International Journal of Computational Fluid Dynamics, **34**: 671-704. https://doi.org/10.1080/10618562.2020.1819535

3 I. Ben Hassan Saïdi, C. Tenaud, and G. Fournier (2021), *Role of the recirculation bubble dynamics on the unsteadiness of the Shock Wave Boundary Layer Interaction.* 25th ICTAM Congress, Aug. 2021, Milano, Italy.

4 I. Ben Hassan Saïdi, G.Fournier, and C. Tenaud (2021), *Contribution of the breathing modes in the SWTBLI unsteadiness.* 55th 3AF International Conference on Applied Aerodynamics, Poitiers, France

5 J.-Ch, Robinet (2007), *Bifurcations in shock-wave/laminar-boundary-layer interaction: global instability approach*, Journal of Fluid Mechanics, **579**: 85-112. https://doi.org/10.1017/S0022112007005095

6 F. Guiho, F. Alizard and J.-Ch, Robinet (2016), *Instabilities in oblique shock wave/laminar boundary-layer interactions*, Journal of Fluid Mechanics, **789**: 1-35. https://doi.org/10.1017/jfm.2015.729

7 G. Aubard, X. Gloerfelt and J.-Ch, Robinet (2013), *Large-Eddy Simulation of Broadband Unsteadiness in a Shock/Boundary-Layer Interaction*, AIAA Journal, **51**: 2395-2409. https://doi.org/10.2514/1.J052249

8 B. Bugeat, J.-Ch. Robinet, J.-C. Chassaing and P. Sagaut (2022), *Low-frequency resolvent analysis of the laminar oblique shock wave/boundary layer interaction*, Journal of Fluid Mechanics, **942**: A43. doi:10.1017/jfm.2022.390

ParisTech

Arts et Métiers

TITLE: EXPERIMENTAL AND NUMERICAL STUDY OF THE FORGEABILITY OF A WIRE ARC ADDITIVE MANUFACTURED (WAAM) PREFORM, APPLICATION TO LARGE MULTI-MATERIAL PARTS

Topic number : ***2022_026***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:https://lcfc.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Langlois Laurent laurent.langlois@ensam.eu
Advisor 2: Zimmer-Chevret Sandra sandra.chevret@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The forming route of large parts, in different industrial sectors (Transportation, energy...), mainly consists in stamping a preform obtained by open die forging. The capabilities and the variabilities of the open die forging necessitate the oversizing of the initial billet in order to obtain after stamping a forged part without defect and meeting its geometrical requirements. The associated excess of material and energy is detrimental to the production efficiency.
The objective of the proposed work is to study the opportunity to manufacture the preform by Wire Arc Additive Manufacturing (WAAM) instead of open die forging. The expected advantages of this solution lie in a better control of the geometry and the oppportunity to use different materials for the different zones of the preform depending on the final part requirements. Because of the extended capabilities of the additive manufacturing, "any" geometry of the preform can be considered, presenting thus a great advantage for the stamping optimization.
The main scientific difficulty corresponds to the chracaterization of the global forgeability of a WAAM manufactured preform. Indeed, the wire-arc additive manufactured part macrostructure consists of layers made of juxtaposed and overlaped weld beads. The structure is thus

heterogeneous with alternation of solidification and annealed zones. The plasticity behavior and, more particularly, the hot ductility of such a structure is, to this day, unknown. Moreover, the surface of the additive manufactured part exhibits waves that might generate folds during stamping.
The proposed approach consists in designing and implementing a forgeability test specially dedicated to WAAM additive manufactured samples. The numerical simulation of the test will be developed in parallel and experimental and numerical results will be compared in order to allow the identification of the plasticity behavior law, and of the ductility criterion. The material analysis of the WAAM preform before and after forging will allow to identify and characterize the metallurgical improvement provided by the hot deformation in terms of homogeneity (grain size, hardness,...).

Required background of the student: Mechanical engineering bases (Manufacturing processes), Material science bases (Mainly concerning steels), numerical simulation bases (Finite Element Simulation)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. J. Wang, L. Langlois, M. Rafiq, R. Bigot, H. Lu, 2014, "Study of the hot forging of weld cladded work pieces using upsetting tests", Journal of Materials Processing Technology, 214 pp 365-379
2. Z. Wang, S. Zimmer-Chevret, F. Léonard, G. Abba, 2022, "Control of bead geometry using multiple model approach in wire-arc additive manufacturing (WAAM)", International Journal of Advanced Manufacturing Technology, 122(7) pp 2939-2951
3. C. Bourlet, S. Zimmer-Chevret, R. Pesci, R. Bigot, A. Robineau, F. Scandella, 2020, "Microstructure and mechanical properties of high strength deposits obtained by Wire-Arc Additive Manufacturing", Journal of Materials Processing Technology, 285
4.
5.

Illustrations :

ParisTech

Arts et Métiers

TITLE: MECHANICAL AND FUNCTIONAL FATIGUE BEHAVIOR OF LASER POWDER BED FUSION PROCESSED NITI SHAPE MEMORY ALLOY

Topic number : ***2022_027***

Field : Material science, Mechanics and Fluids, Energy, Processes,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location:
Lab website:https://www.msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: EL Mansori Mohamed mohamed.elmansori@ensam.eu
Advisor 2: KANG Nan nan.kang@ensam.eu
Advisor 3: YU Tianyu tianyuyu@hit.edu.cn
Advisor 4:

Short description of possible research topics for a PhD: Shape memory alloys (SMAs) are one class of materials exhibiting functional properties, which can return to a predetermined shape when heated. To fully utilize these properties, NiTi needs to be processed into various geometries for different applications. However, conventional manufacturing methods have several limitations including the contamination of the crucible by oxygen. In addition, NiTi is a material that is difficult to process due to its compositional sensitivity and poor machinability. Recently, Laser Powder Bed Fusion (L-PBF) has been considered as one possible near net-shaped process to overcome these shortages. In this project, the mechanical and functional fatigue behavior of LPBF processed NiTi will be investigated. The correlation analyses between fatigue life and the factors of surface roughness, porosity, and residual stress will be evaluated. The crack behavior at different stage will be characterized using the X-ray CT instrument for obtaining an effective fatigue prediction method. The synergistic effects of part densification, residual stress, and microstructure variable will be quantified to assess the fatigue performance.

Required background of the student: 1. Candidates should have a master degree in materials science or mechanical engineering;
2. A background in additive manufacturing, laser materials processing will be a clear advantage;
3. The Fatigue behavior investigation experience on LPBF processed component is preferred;
4. Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Ayati, P., Safaei, K., Nematollahi, M., Jahadakbar, A., Yadollahi, A., Mahtabi, M., Elahinia, M. Toward understanding the effect of remelting on the additively manufactured NiTi (2021) International Journal of Advanced Manufacturing Technology, 112 (1-2), pp. 347-360.
2. (2) Bayati, P., Jahadakbar, A., Barati, M., Nematollahi, M., Saint-Sulpice, L., Haghshenas, M., Chirani, S.A., Mahtabi, M.J., Elahinia, M. Toward low and high cycle fatigue behavior of SLM-fabricated NiTi: Considering the effect of build orientation and employing a self-heating approach (2020) International Journal of Mechanical Sciences, 185, art. no. 105878.
3. Speirs, M., Van Hooreweder, B., Van Humbeeck, J., Kruth, J.-P. Fatigue behaviour of NiTi shape memory alloy scaffolds produced by SLM, a unit cell design comparison (2017) Journal of the Mechanical Behavior of Biomedical Materials, 70, pp. 53-59.
4.
5.

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: INVESTIGATION ON MICROSTRUCTURE AND STRENGTHEN MECHANISM OF LASER POWDER BED FUSION HIGH TEMPERATURE MULTI-REINFORCED AL MATRIX COMPOSITE

Topic number : ***2022_028***

Field : Material science, Mechanics and Fluids, Energy, Processes,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: MSMP - Laboratoire Mécanique, Surface, Matériaux et Procédés
Lab location:
Lab website:https://www.msmp.eu

Contact point for this topic: Arts et Métiers

Advisor 1: KANG Nan nan.kang@ensam.eu
Advisor 2: El Mansori Mohamed mohamed.elmansori@ensam.eu
Advisor 3: CHEN Biao chen@nwpu.edu.cn
Advisor 4:

Short description of possible research topics for a PhD: For meeting the requirements in complexity and lightweight design of components (200℃-350℃) in next generation aircraft, development of the novel high-temperature Al with low cost for laser powder bed fusion (LPBF) will bring new opportunities to the materials design and intelligent manufacturing fields. Based on the above, from the intrinsic features of LPBF processed sample with non-equilibrium solidification and multi-scales heterogeneous structure, this work aims to obtain the design strategy for LPBF high temperature Al matrix composite by manufacturing the metastable intermetallics and quasicrystalline phase reinforced nano-composite structure. Focusing on the formation and controlling mechanism of metastable heterogeneous structure and corresponding multi-scales deformation and strengthen behaviors, the composite will be firstly designed using high throughput method with rapid solidification theory. Then, the relationship between alloy composition-process parameters-structure-properties of LPBF processed Al matrix composite will be established for guiding the realization of materials-structure-function additive manufacturing of multi-scales reinforced Al matrix composite.

Required background of the student: 1. Candidates should have a master degree in materials science or mechanical engineering;
2. A background in additive manufacturing, laser materials processing will be a clear advantage;
3. The microstructure and mechanical behavior investigation experience on LPBF processed component is preferred;
4. Candidates should be able to work in a multidisciplinary environment and be fluent in English (both oral and written)

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. N.T. Aboulkhair, M. Simonelli, L. Parry, I. Ashcroft, C.Tuck, R. Hague, 3D printing of Aluminium alloys: Additive Manufacturing of Aluminium alloys using selective laser melting, Progress in Materials Science, 106 (2019) 100578.

2. R.A. Michi, A. Plotkowski, A. Shyam, R.R. Dehoff, S.S. Babu, Towards high-temperature applications of aluminium alloys enabled by additive manufacturing, Int. Mater. Rev., 67:3 (2022) 298-345.

3. N. Kang, M. El Mansori, X. Lin, F. Guittonneau, H.L. Liao, W.D. Huang, C. Coddet, In-situ synthesis of aluminum/nano-quasicrystalline Al-Fe-Cr composite by using selective laser melting, Composites Part B: Engineering, 155 (2018) 382-390.

4.

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Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: MULTI-SCALE DATA-DRIVEN MODELLING OF SHORT-FIBRE REINFORCED COMPOSITES FOR AUTOMOTIVE APPLICATIONS

Topic number : ***2022_029***

Field : Material science, Mechanics and Fluids, ,

Subfield: Computational mechanics, Mechanics of Materials, multi-scale modelling, data-driven modelling

ParisTech School: Arts et Métiers
Research team:
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Meraghni Fodil fodil.meraghni@ensam.eu
Advisor 2: Praud Francis francis.praud@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Short-fibre reinforced composites have shown to be among the best candidates to replace the actual metallic structural components in a view to reduce the mass of vehicles in the automotive industry. This is due to their remarkable properties induced by the association of stiff and tough glass fibre reinforcements with lightweight thermoplastic matrices. However, the use of such composites gives rise to highly complex mechanical responses that strongly depend on the fibre orientation, itself linked with the moulding process as fibres tends to be oriented along the moulding flow direction. Furthermore, the mechanical behaviour of these composites is also strongly influenced by the thermoplastic matrix, which exhibits both fluid and solid properties coupled to damage mechanisms . For these reasons, short-fibre reinforced composites have an anisotropic and time-dependent behaviour resulting from the microstructure arrangement, the complex rheological behaviour of the matrix and the fibre/matrix interface degradation mechanisms occurring at the scale of the microstructure.
Over the past years, many experimental and modelling efforts have been undertaken to better understand this type of composite. On the modelling

side, multi-scale modelling techniques either employing mean-field or full-field theories have been developed to predict the macroscopic response of these composites in relation with the local behaviour of the constituents and the arrangement of the microstructure. Although these approaches provided promising results in good agreement with experimental data, the significant computational cost and the important number of microstructural parameters hamper its practical use in structure analysis.
To overcome this limitation, the objective of the proposed PhD thesis is to investigate the use of data-driven modelling techniques such as non-intrusive PGD (Proper Generalized Decomposition) to efficiently deal with the simulations of short-fibre reinforced composites for which many microstructural parameters are involved. Indeed, PGD has been used in different multi-parametric problems involved in science and engineering fields, by assuming each parameter as an extra-coordinate of the model. Therefore, approximated responses of the composite can be determined by multi-dimensional regression using a precomputed dataset of offline solutions.

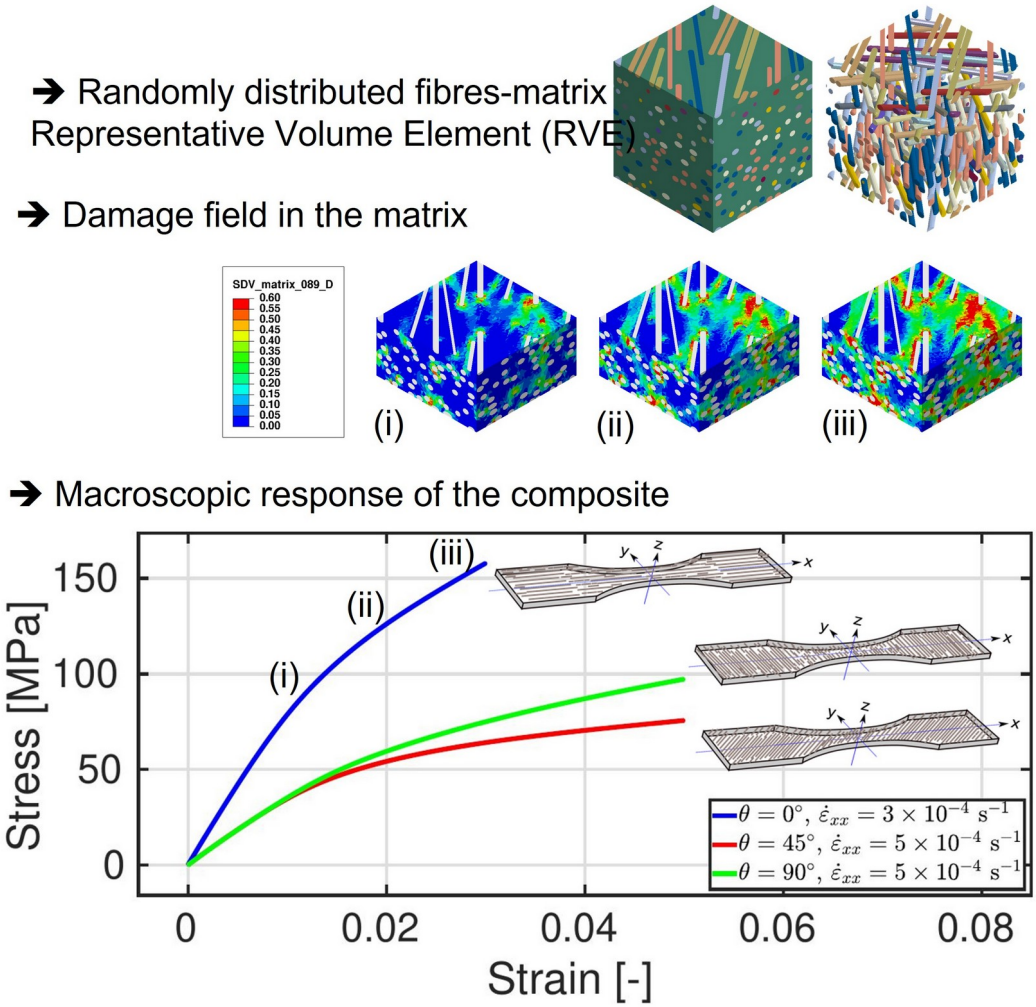
Required background of the student: Good knowledge in Continuum mechanics, Finite element method and scientific programming are required. Skills in constitutive modelling, multi-scale modelling and data-driven modelling will also be appreciated

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. F. Praud, G. Chatzigeorgiou, J. Bikard and F. Meraghni, Phenomenological multimechanisms constitutive modelling for thermoplastic polymers, implicit implementation and experimental validation, Mechanics of Materials, 114:9–29, 2017
2. Q. Chen, G. Chatzigeorgiou and F. Meraghni, Extended mean-field homogenization of viscoelastic-viscoplastic polymer composites undergoing hybrid progressive degradation induced by interface debonding and matrix ductile damage, International Journal of Solids and Structures, 210-211:91–17, 2021.
3. K. Schneider, B. Klusemann, and S. Bargmann, Automatic three-dimensional geometry and mesh generation of periodic representative volume elements for matrix-inclusion composites, Advances in Engineering Software, 99:177–188, 2016.
4. F. Praud, G. Chatzigeorgiou, and F. Meraghni, Fully integrated multi-scale modelling of damage and time-dependency in thermoplastic-based

woven composites, International Journal of Damage Mechanics, 30:163–195, 2021.
5. M. El Fallaki Idrissi, F. Praud, V. Champaney, F. Chinesta, F. Meraghni, Multiparametric modeling of composite materials based on non-intrusive PGD informed by multiscale analyses: Application for real-time stiffness prediction of woven composites, Composite Structures, vol 302, 116228, 2022.

Illustrations :



ParisTech

Arts et Métiers Sciences et Technologies

TITLE: ELASTIC TURBULENCE IN CURVILINEAR GEOMETRIES

Topic number : ***2022_031***

Field : Material science, Mechanics and Fluids, Energy, Processes,

Subfield:

ParisTech School: Arts et Métiers
Research team: A. Dazin (Arts et Métiers), F. Romanò (Arts et Métiers), S. Berti, E. Calzavarini and G. Mompean (UML, Lille), V. Bertola (Univ. Liverpool), T. Burghelea (CNRS ,Nantes)
Research lab: LMFL - Laboratoire de mécanique des fluides de Lille
Lab location: Lille
Lab website:https://lmfl.cnrs.fr/en/home/

Contact point for this topic: Arts et Métiers

Advisor 1: DAZIN Antoine antoine.dazin@ensam.eu
Advisor 2: ROMANO Francesco francesco.romano@ensam.eu
Advisor 3: BERTI Stefano stefano.berti@polytech-lille.fr
Advisor 4:

Short description of possible research topics for a PhD: One of the most remarkable effects of highly viscous polymer solutions that has been recently observed in experiments is the development of an elastic turbulence regime in the limit of strong elasticity. The flow of polymer solution in this regime displays irregularities typical of turbulent flows even at low velocity and high viscosity (i.e., for vanishing Reynolds number). As a consequence of turbulent motion at small scales, elastic turbulence can reveal as an efficient technique for mixing in very low Reynolds flows (e.g., in microchannels). Despite its great technological interest, elastic turbulence is still only partially understood from a fundamental point of view.

During this PhD project, we will build up on the results obtained in a previous stage that demonstrated the numerical reproducibility of the elastic turbulence in a 2D Taylor-Couette (fig. 1, left) and a 2D serpentine channel (fig. 1, right). The analysis will focus on the Eulerian and Lagrangian mixing properties in these two setups, with the aim to relate them to the statistical behavior of velocity fluctuations as a function of the flow elasticity and the polymer concentration.

This project is conceived as a stepstone towards the investigation of the phenomenon of emulsification in elastic turbulence.

Required background of the student: Education in Fluid mechanics, Physics, Applied Mathematics. Good knowledge of fluid mechanics and an interest for numerical methods. Good knowledge of oral and written English is required. Knowing a programming language (Python, C, Fortran) would be a plus.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Berti, S., Bistagnino, A., Boffetta, G., Celani, A., & Musacchio, S. (2008). Two-dimensional elastic turbulence. Physical Review E, 77(5), 055306.

2. Romanò, F., Albensoeder, S., & Kuhlmann, H. C. (2017). Topology of three-dimensional steady cellular flow in a two-sided anti-parallel lid-driven cavity. Journal of Fluid Mechanics, 826, 302-334.

3. Canossi, D. O., Mompean, G., & Berti, S. (2020). Elastic turbulence in two-dimensional cross-slot viscoelastic flows. EPL (Europhysics Letters), 129(2), 24002.

4. Garg, H., Calzavarini E., & Berti S. (2021). Statistical properties of two-dimensional elastic turbulence. Physical Review E, 104, 035103.

5.

Illustrations :

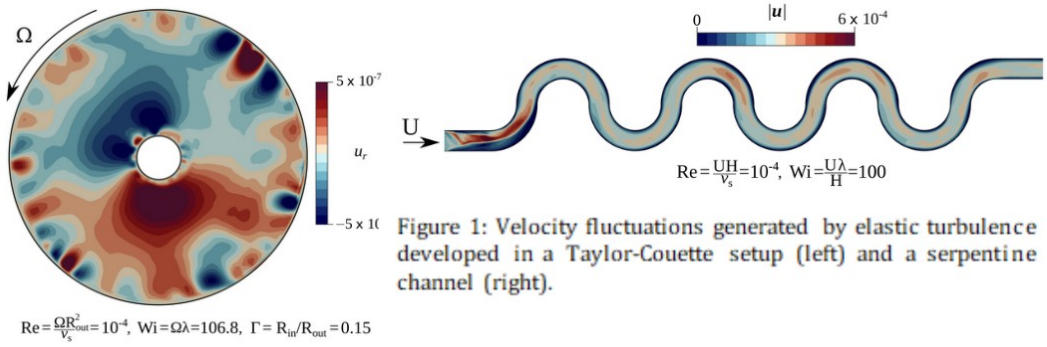


Figure 1: Velocity fluctuations generated by elastic turbulence developed in a Taylor-Couette setup (left) and a serpentine channel (right).

TITLE: DYNAMIC CRACK PROPAGATION IN MULTIDIRECTIONAL FUNCTIONALLY GRADED MATERIALS UNDER MECHANICAL AND THERMAL LOADINGS

Topic number : ***2022_032***

Field : Material science, Mechanics and Fluids, Material science, Mechanics and Fluids, Mathematics and their applications

Subfield:

ParisTech School: Arts et Métiers
Research team: Structures et Ecoulements Complexes (SEC)
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:https://lampa.ensam.eu/accueil-lampa-100748.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: Ammar Amine amine.ammar@ensam.eu
Advisor 2: KAZEMZADEHPARSI Mohammad-Javad mohammadjavad.kazemzadehparsi@ensam.eu
Advisor 3: EL AREM Saber saber.elarem@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Functionally Graded Materials (FGM) are new class of composite materials that their mechanical properties evolve continuously in space. In traditional composite materials, the mechanical properties change sharply at the interface of different phases and this leads to high interfacial stresses and in many times the origin of failure. Whereas, the gradual variation of material properties in FGM materials prevents from such behaviors. This feature makes the FGM as the ideal choice in severe thermal environments and make it possible to have a part with pure metallic phase at one point to satisfy strength and pure ceramic phase at other point to resist again high temperature. One example application of FGM materials is heat barrier in spacecrafts. Optimal design of FGM materials consists of accurate determination of spacial distribution of concentration (or volume fraction) of constituents. Recent technologies use additive manufacturing to produce FGM materials and consequently the FGM parts with multi directional material variations are realistic today.

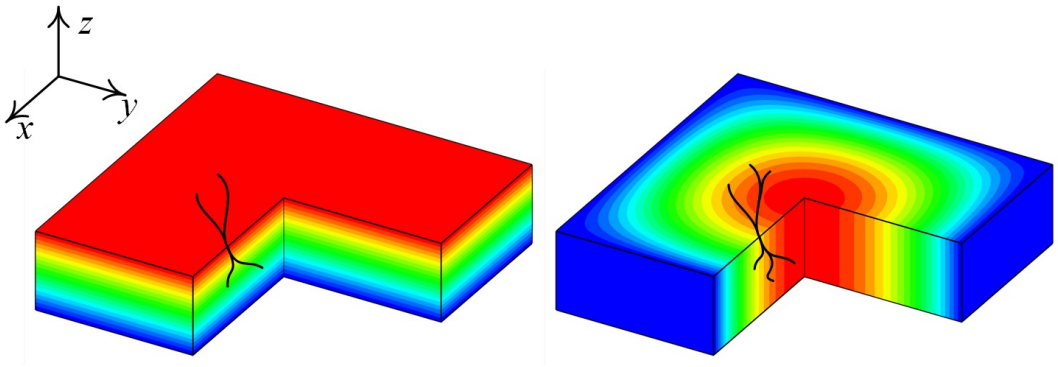
Failure analysis is the inseparable part of any engineering design and crack propagation is the inseparable part of any failure analysis. Therefore, analysis of crack propagation in FGM materials are highly important in optimal design of such products. Phase field approach is the most accurate and versatile technique in moving boundary problems specially crack propagations. The main objective of the present project is to establish a general approach for accurate dynamic crack propagation and failure in components made of FGM materials in the framework of gradient damage approach.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Khakpour, Y. Bazargan-Lari, P. Zahedinejad, M.J. Kazemzadeh-parsi, Vibrations Evaluation of Functionally Graded Porous Beams in Thermal Surroundings by Generalized Differential Quadrature Method, Shock and Vibration, 2022, Article ID 8516971.
2. M. Forghani, Y. Bazargan-Lari, P. Zahedinejad, M.J. Kazemzadeh-Parsi, Nonlinear frequency behavior of cracked functionally graded porous beams resting on elastic foundation using Reddy shear deformation theory, Journal of Vibration and Control, April 21, 2022.
3. M.J Kazemzadeh-Parsi, F. Chinesta, A. Ammar, Proper generalized decomposition for parametric study and material distribution design of multi-directional functionally graded plates based on 3D elasticity solution, Materials, 2021, 14, 6660.
4. M.J. Kazemzadeh-Parsi, A. Ammar, F. Chinesta, Parametric analysis of thick FGM plates based on 3D thermos-elasticity theory: a PGD approach, submitted to Computers & Mathematics with Applications, 2022.
5. Gmati, H, Mareau, C, Ammar, A, El Arem, S. A phase-field model for brittle fracture of anisotropic materials. Int J Numer Methods Eng. 2020; 121: 3362– 3381.

Illustrations :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ParisTech

ESPCI PARIS PSL

TITLE: BIO-INSPIRED FLEXIBLE PLATES FOR SURFACE WAVE ENERGY CONVERSION

Topic number : ***2022_033***

Field : Material science, Mechanics and Fluids, Energy, Processes,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: BIOMIM https://www.pmmh.espci.fr/Biomimetics-and-Fluid-Structure-Interaction
Research lab: PMMH - Physique et mécanique des Milieux Hétérogènes
Lab location: Paris
Lab website:https://www.pmmh.espci.fr/

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Godoy-Diana Ramiro ramiro@pmmh.espci.fr
Advisor 2: Thiria Benjamin bthiria@pmmh.espci.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The present project aims at studying the interactions of a horizontal flexible plate with incoming waves, which could be used in future designs coupling wave energy conversion to coastal protection. The chosen design draws inspiration from underwater aquatic vegetation that deforms and undulates in response to passing waves thus dissipating wave energy.

The hosting team at PMMH, ESPCI Paris is currently performing a first study on an experimental setup dedicated to this problem, measuring the wave energy transmission and reflection by a submerged horizontal flexible plate that can bend under the action of the wave-induced pressure difference above and below its surface. Preliminary observations of a jet flow produced by the membrane when its motion is strongly coupled to the incoming waves hint on the reason why the usual potential-flow modeling of ocean surface waves (with its effects incorporated as hydrodynamic pressure in a beam equation that describes the deformation of the membrane) fails to predict the measured transmission and reflection coefficients. In the present project we propose to perform a full experimental characterization of this jet flow

(using particle image velocimetry), its interaction with the membrane, and its effect on the energy balance. The quantitative evaluation of the latter being the main global objective, together to bringing new physical insight to the modelling of such strongly-coupled fluid-structure interaction problems.

Required background of the student: Fluid mechanics. PIV

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. On the interaction of surface water waves and fully-submerged elastic plates

G. Polly, A. Mérigaud, R. Alhage, B. Thiria & R. Godoy-Diana

In Proceedings of the 11th European Wave and Tidal Energy Conference, 5-9th Sept 2021, Plymouth, UK.

preprint: arXiv:2111.03018

2. A wide-spacing approximation model for the reflection and transmission of water waves over an array of vertical obstacles

A. Mérigaud, B. Thiria & R. Godoy-Diana

Journal of Fluid Mechanics 923, A2 (2021)

doi: 10.1017/jfm.2021.532

3. Surface wave energy absorption by a partially submerged bio-inspired canopy

C. Nové-Josserand, F. Castro Hebrero, L.-M. Petit, W. Megill, R. Godoy-Diana & B. Thiria

Bioinspiration & Biomimetics 13, 036006 (2018)

doi: 10.1088/1748-3190/aaae8c

4.

5.

Illustrations :

TITLE: TOWARDS DIGITAL TWINS FOR THE OPTIMIZATION OF THE COPPER BASED SHAPE MEMORY ALLOYS WITH HIGH ENTROPY

Topic number : ***2022_034***

Field : Material science, Mechanics and Fluids, Material science, Mechanics and Fluids, Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team: SMART Research Group
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: MERAGHNI Fodil fodil.meraghni@ensam.eu
Advisor 2: THIERCELIN Léo leo.thiercelin@ensam.eu
Advisor 3: PELTIER Laurent laurent.peltier@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Copper based Shape Memory Alloys (CuAl-like) represent a class of SMAs with remarkable properties such as memory effect or superelasticity. The latter allows higher levels of deformation than standard alloys when the memory effect allows the material to recover its initial shape under the effect of temperature. These alloys are generally employed for aerospace or automotive application. However, they lose their actuation features when they are subjected to high temperatures (between 300 and 700 °C). One solution consists to develop High Entropy Alloys (HEA) with shape memory properties to improve the thermomechanical behavior of "classical" SMAs at high temperatures.
The objective of this project is the development of an experimental methodology aimed at designing, manufacturing and characterizing a new class of CuAl-like HE-SMAs, which are able to resist and to keep their mechanical properties at high temperature. The properties of these new high-entropy alloys should improve the high-temperature durability of usual polycrystalline copper-based SMAs.
Thermodynamics based and chemical criteria will have to be firstly defined in order to obtain a single-phase solution and suitable

transformation temperatures. Based on these criteria, several candidate materials with selected chemical compositions will then be developed and studied by microstructural (X-ray diffraction, DSC tests, SEM observations) and mechanical (memory effect, superelastic, damping effect) analyses over a wide temperature range.
The data from the microstructural and thermomechanical analyses will be collected in an experimental database for the development of a digital twin founded on deep machine learning algorithms. The latter will be employed to provide reliable predictions of the thermomechanical properties of the developed HE-SMAs as a function of the their alloying chemical composition and the thermal treatments. Thanks to the prediction tools enriched by experimental database, the initially proposed elaboration criteria will be enhanced and/or reformulated to produce an optimized alloy whose mechanical properties will be studied and compared with those of the alloys proposed at the beginning of the project.

Required background of the student: Materials Science, Mechanics of materials

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. PELTIER L, LOHMULLER P, MERAGHNI F, BERVEILLER S, PATOOR E, LAHEURTE P. Investigation and Composition Characterization of a “NiTi-like” Alloy Combining High Temperature Shape Memory and High Entropy. Shape Mem Superelasticity 2020. 6(2), pp. 273-283
2. PELTIER L, BERVEILLER S, MERAGHNI F, LOHMULLER P, LAHEURTE P. Martensite Transformation and Superelasticity at High Temperature of (TiHfZr)74(NbTa)26 High-Entropy Shape Memory Alloy. Shape Memory and Superelasticity, 2021. 1–12. https://doi.org/10.1007/s40830-021-00323-4 7, pages194–205 (2021)
3. PELTIER L, MERAGHNI F, BERVEILLER S, LOHMULLER P, LAHEURTE P. Relationship between Chemical Composition and Ms Temperature in High-Entropy Shape Memory Alloys. Shape Memory and Superelasticity, 2021. doi:10.1007/s40830-021-00342-1.
4. Peltier, L., Lohmuller, P., Meraghni, F., Patoor, E., Laheurte, P., & Berveiller, S. (2022). Damping Behavior in a Wide Temperature Range of FeMn-Like High Entropy Shape Memory Alloys. Shape Memory and Superelasticity. https://doi.org/10.1007/s40830-022-00381-2
5.

Illustrations :

Towards digital twins for the optimization of the copper based shape memory alloys with high entropy

Field : 8. Materials Science, Mechanics, Fluids
Title: **Toward a digital twin for the optimization of the copper based shape memory alloys with high entropy**

ParisTech School: Arts et Metiers Institute of Technology
Advisors Names, E-mails: Prof. Fodil Meraghni, fodil.meraghni@ensam.eu
Dr. Léo Thiercelin, leo.thiercelin@ensam.eu
Dr. Laurent Peltier, laurent.peltier@ensam.eu

Research group/Lab: **SMART** research group **/ LEM3 UMR CNRS 7239** National Key Lab (Metz)

Copper based Shape Memory Alloys (CuAl-like) represent a class of SMAs with remarkable properties such as memory effect or superelasticity. The latter allows higher levels of deformation than standard alloys when the memory effect allows the material to recover its initial shape under the effect of temperature. These alloys are generally employed for aerospace or automotive application. However, they lose their actuation features when they are subjected to high temperatures (between 300 and 700 °C). One solution consists to develop High Entropy Alloys (HEA) with shape memory properties to improve the thermomechanical behavior of "classical" SMAs at high temperatures [1-4].

The objective of this project is the development of an experimental methodology aimed at designing, manufacturing and characterizing a new class of CuAl-like HE-SMAs, which are able to resist and to keep their mechanical properties at high temperature. The properties of these new high-entropy alloys should improve the high-temperature durability of usual polycrystalline copper-based SMAs.

Thermodynamics based and chemical criteria will have to be firstly defined in order to obtain a single-phase solution and suitable transformation temperatures. Based on these criteria, several candidate materials with selected chemical compositions will then be developed and studied by microstructural (X-ray diffraction, DSC tests, SEM observations) and mechanical (memory effect, superelastic, damping effect) analyses over a wide temperature range.

The data from the microstructural and thermomechanical analyses will be collected in an experimental database for the development of a digital twin founded on deep machine learning algorithms. The latter will be employed to provide reliable predictions of the thermomechanical properties of the developed HE-SMAs as a function of the their alloying chemical composition and the thermal treatments. Thanks to the prediction tools enriched by experimental database, the initially proposed elaboration criteria will be enhanced and/or reformulated to produce an optimized alloy whose mechanical properties will be studied and compared with those of the alloys proposed at the beginning of the project.

References

[1] PELTIER L, LOHMULLER P, MERAGHNI F, BERVEILLER S, PATOOR E, LAHEURTE P. Investigation and Composition Characterization of a "NiTi-like" Alloy Combining High Temperature Shape Memory and High Entropy. Shape Mem Superelasticity 2020. 6(2), pp. 273-283

[2] PELTIER L, BERVEILLER S, MERAGHNI F, LOHMULLER P, LAHEURTE P. Martensite Transformation and Superelasticity at High Temperature of (TiHfZr)74(NbTa)26 High-Entropy Shape Memory Alloy. Shape Memory and Superelasticity, 2021. 1–12. https://doi.org/10.1007/s40830-021-00323-4 7, pages194–205 (2021)

[3] PELTIER L, MERAGHNI F, BERVEILLER S, LOHMULLER P, LAHEURTE P. Relationship between Chemical Composition and Ms Temperature in High-Entropy Shape Memory Alloys. Shape Memory and Superelasticity, 2021. doi:10.1007/s40830-021-00342-1.

[4] PELTIER, L., LOHMULLER, P., MERAGHNI, F., PATOOR, E., LAHEURTE, P., & BERVEILLER, S. (2022). Damping Behavior in a Wide Temperature Range of FeMn-Like High Entropy Shape Memory Alloys. Shape Memory and Superelasticity. https://doi.org/10.1007/s40830-022-00381-2

TITLE: DEVELOPMENT OF ADVANCED MULTISCALE COMPUTATIONAL TOOLS AND DATA-DRIVEN TECHNIQUES FOR THE MULTIPHYSICS PREDICTION OF CARBON NANOTUBES (CNTS) FUZZY FIBER COMPOSITES

Topic number : ***2022_035***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Chatzigeorgiou George georges.chatzigeorgiou@ensam.eu
Advisor 2: Meraghni Fodil fodil.meraghni@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Modern engineering applications require the development of composite materials with advanced mechanical, thermal, electrical etc. properties that provide high performances when employed for structural components. Carbon nanotubes (CNTs) have shown excellent characteristics when introduced in composite structures. A relatively new type of material system considers matrices reinforced with “fuzzy fibers” (fibers with CNTs grown on their surfaces). SiC fibers with grown CNTs are embedded in ceramic matrices towards developing lightweigt high-heat engine parts in aerospace applications . These complicated heterogeneous materials cannot be studied with the classical multiscale methodologies and they require appropriate micromechanics tools .
The proposed Ph.D. is going to investigate and design computational homogenization strategies (both full-field and mean-field) for composite structures reinforced with fuzzy fibers. The examined multiphysical properties will include mechanical, thermal and electrical properties as well as their coupling. Nonlinear and damage mechanisms will also been taken into account. The numerical implementation of the composite

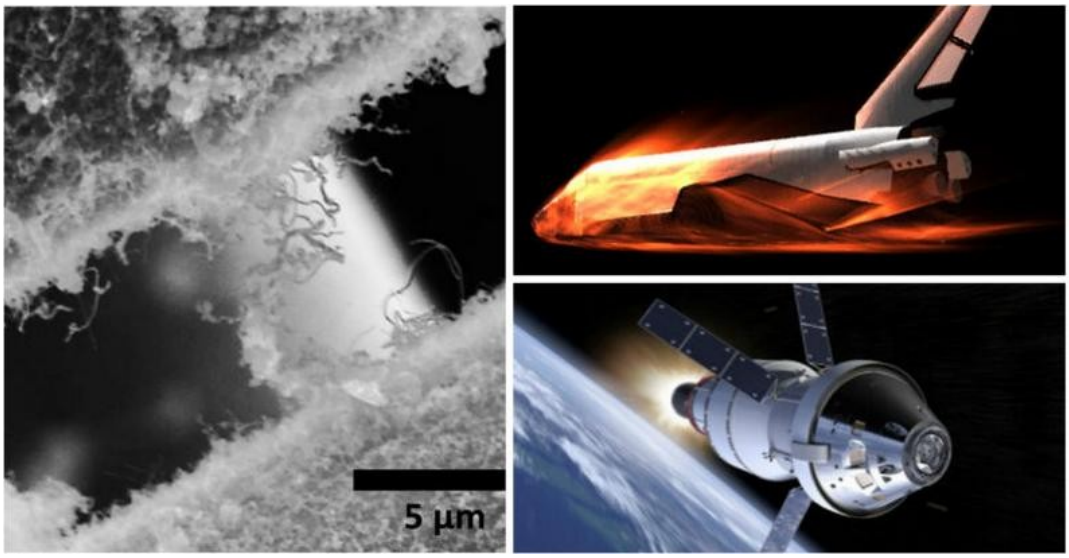
response (identified from the previous steps) in structures and structural components will be achieved using data-driven computational techniques.

Required background of the student: Mechanical engineering, Computational mechanics, Mechanics of Materials.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. A.H.C. Hart, R. Koizumi, J. Hamel et al. (2017), “Velcro-Inspired SiC Fuzzy Fibers for Aerospace Applications”, ACS Applied Materials & Interfaces, Vol. 9(15), pp. 13742–13750.
2. G. Chatzigeorgiou, F. Meraghni, N. Charalambakis, A. Benaarbia (2020), “Multiscale modeling accounting for inelastic mechanisms of fuzzy fiber composites with straight or wavy carbon nanotubes”, International Journal of Solids and Structures, Vol. 202, pp. 39–57.
3. Q. Chen, G. Chatzigeorgiou, F. Meraghni (2021), “Hybrid hierarchical homogenization theory for unidirectional CNTs-coated fuzzy fiber composites undergoing inelastic deformations”, Composites Science and Technilogy, Vol. 215, pp. 109012.
4. Q. Chen, G. Chatzigeorgiou, F. Meraghni (2022), “Recursive multiscale homogenization of multiphysics behavior of fuzzy fiber composites reinforced by hollow carbon nanotubes”, Journal of Intelligent Material Systems and Structures, in press.
5.

Illustrations :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ParisTech

Arts et Métiers

TITLE: MOOC IN VIRTUAL REALITY: LEARNING THROUGH VOLUMETRIC CAPTURE OF LECTURE

Topic number : ***2022_036***

Field : Information and Communication Science and Technology, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: Presence & Innovation
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:https://lampa.ensam.eu/accueil-lampa-100748.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: Fleury Sylvain sylvain.fleury@ensam.eu
Advisor 2: Richir Simon simon.richir@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The proposed research project aims at investigating the potential of immersive technologies (virtual reality, augmented reality, extended reality - XR) to teach and learn technical and/or scientific contents. Virtual and augmented reality have developed rapidly over the last twenty years, both in terms of hardware and software quality, which offers several potentialities and use cases. In parallel, the metaverse is being built to facilitate collaboration and mutual support between distant learners. However, these technologies remain under-exploited in several fields. The digital learning transformation, particularly in higher education and professional training, requires further investigations in order to adapt to the cognitive characteristics of learners and to develop pedagogical approaches that integrate these technologies in a relevant way.
Mooc courses have difficulties in generating engagement among all learners. The use of immersive technologies in this context could be interesting to improve the attractiveness of Mooc. The objective will be to use state-of-the-art hardware to capture teaching sequences volumetrically so that they can be viewed as a “VR Mooc”. The teaching sequences will thus be explored entirely in 3D by the learners who will be

able to move around the scene, replay the sequence, collaborate, etc. The thesis will focus on the evaluation of the pedagogical effectiveness of this type of device, and on the development and evaluation of innovative approaches to enrich these immersive Mooc (attentional guidance techniques, visual information display in the scene, etc.). Attention could also be paid to the addition of virtual agents or avatar characteristics. Evaluations could focus on learning performance (memorization, understanding, abilities to reproduce a task in realistic context), participants involvement, but also on learners' satisfaction in order to guarantee the acceptability of the technologies used in such contexts.

This work will lead to high-level international publications that will shed light on relevant pedagogical tools and good practices for learning using immersive technologies.

Required background of the student: Master's degree in computer science with extended knowledge of virtual reality. We are looking for a candidate with an interest in multidisciplinary research, at the frontier of virtual reality and experimental psychology. A strong interest for experimental research is required: production of protocols, conducting experiments, data analysis and writing. Applicants are expected to read, speak and write academic english.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Buttussi, F., & Chittaro, L. (2017). Effects of different types of virtual reality display on presence and learning in a safety training scenario. IEEE transactions on visualization and computer graphics, 24(2), 1063-1076.
2. El Kabtane, H., El Adnani, M., Sadgal, M., & Mourdi, Y. (2020). Virtual reality and augmented reality at the service of increasing interactivity in MOOCs. Education and Information Technologies, 25(4), 2871-2897.
3. Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. Journal of Computers in Education, 8(1), 1-32.
4. Hew, K. F., & Cheung, W. S. (2010). Use of three-dimensional (3-D) immersive virtual worlds in K-12 and higher education settings: A review of the research. British journal of educational technology, 41(1), 33-55.
5. Hewawalpita, S., Herath, S., Perera, I., & Meedeniya, D. (2018). Effective Learning Content Offering in MOOCs with Virtual Reality-An

Exploratory Study on Learner Experience. J. Univers. Comput. Sci., 24(2), 129-148.

Illustrations :

TITLE: IMPROVING FORMABILITY OF LIGHTWEIGHT METALLIC MATERIALS USING PROCESS CHAINING: INCREMENTAL FORMING AND FRICTION STIR WELDING

Topic number : ***2022_037***

Field : Energy, Processes, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Arts et Métiers
Research team: Pr. Philippe DAL SANTO, Dr. Tudor BALAN, Dr. Sandra CHEVRET, Dr. Idriss TIBA
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:http://lampa.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Dal Santo Philippe philippe.dalsanto@ensam.eu
Advisor 2: Tiba Idriss idriss.tiba@ensam.eu
Advisor 3: Chevret Sandra sandra.chevret@ensam.eu
Advisor 4: Balan Tudor tudor.balan@ensam.eu

Short description of possible research topics for a PhD: The current trends of the “industry of the future” include dramatic product customization (small batch production) along with optimized lightweight construction, in particular in transportation industries. Innovative technologies to answer these challenges include robotized forming and assembly processes like single point incremental forming (SPIF) and friction stir welding (FSW), in conjunction with sheet aluminum alloys. Developed during the last two decades, these promising processes still exhibit numerous scientific and technological challenges. Process chaining, on the same part and robot, would allow for a deeper optimization at an improved cost, allowing for the right material at the right place; however, the impact of assembly on the residual formability is little known. Establishing the relationship between process parameters and part quality after welding and further forming would be a significant achievement. Controlling the sheet temperature is one of the promising directions to further improve the formability. The final objective is to propose a numerical approach to simulate the forming processes including the chaining effects. Depending on the abilities of the

candidate, one or the other of these research directions will be further developed.

Required background of the student: The student must have very good knowledge in forming processes of metallic materials and in numerical simulation. Some background in metallurgy will be also appreciated.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Y. Yang and T. Balan. Prediction of the yield surface evolution and some apparent non normality effects after abrupt strain-path change using classical plasticity. Int. Journal of Plasticity (2019), 119; 331-343.
2. D. Rou et al. Experimental and numerical investigation of the mechanical behavior of the AA5383 alloy at high temperatures. Journal of Materials Processing Technology (2020), 281; art. no. 116609.
3. K. Kolegain et al. Off-line path programming for three-dimensional Robotic Friction Stir Welding based on Bézier curves. Industrial Robot: An International Journal (2018).
4. S. Boudhaouia et al. Experimental and numerical study of a new hybrid process: multi-point incremental forming (MPIF). International Journal of Material Forming (2018), 11; 815–827.
5.

Illustrations :

Friction Stir Welding
on ABB IRB 8700 robot

SPIF
on ABB IRB 8700 robot

ParisTech

ESPCI PARIS PSL

TITLE: DYNAMICAL SOFT HYDRAULICS OF COMPLEX FLUIDS

Topic number : ***2022_038***

Field : Material science, Mechanics and Fluids, Physics, Optics,

Subfield: Soft matter, elastohydrodynamics

ParisTech School: ESPCI Paris - PSL
Research team: Interfacial dynamics of soft matter
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location: Paris
Lab website:https://www.gulliver.espci.fr/

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: MCGRAW Joshua joshua.mcgraw@espci.fr
Advisor 2: Restagno Frédéric frederic.restagno@universite-paris-saclay.fr
Advisor 3:
Advisor 4:

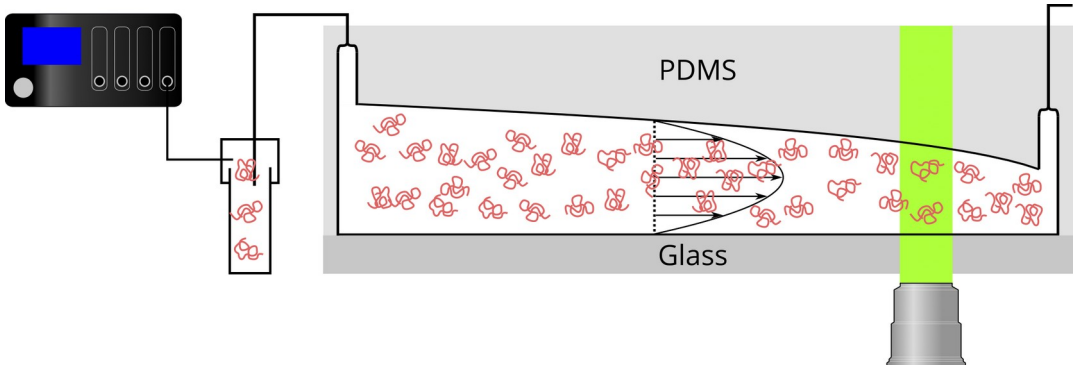
Short description of possible research topics for a PhD: To force a liquid to pass through a narrow channel, a pressure needs to be applied across its ends. For the case in which the walls containing the fluid are compliant, a rich phenomenology has been observed, including non-linear flow rate/pressure relations and non-trivial dynamic responses. Up to now, the elastohydrodynamic case of Newtonian fluids is well described for both phenomena. However, the corresponding case of complex fluids remains relatively unexplored, even while such fluids are present in many natural and technological scenarios. In this project, polymer solutions will be used as model complex fluids, characterized by a molecular relaxation time and, possibly, a nontrivial hydrodynamic boundary condition. The PhD student participating in this project will study such solutions using interferometric and evanescent optics in microfluidic flow domains, while making simultaneous pressure and flow-rate measurements. The work will be carried out in the Gulliver laboratory, and at the IPGG microfluidic institute in the heart of Paris. Highly motivated students are warmly invited to make contact.

Required background of the student: Physics, soft condensed matter, experiments

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. https://hal.archives-ouvertes.fr/hal-03719718
2. https://doi.org/10.1039/D0SM02116D
3. https://iopscience.iop.org/article/10.1088/1361-648X/ac327d
4.
5.

Illustrations :



ParisTech

ESPCI PARIS PSL

TITLE: DIFFUSIVE AND HYDRODYNAMIC MOTION NEAR SOFT AND POROUS MEDIA

Topic number : ***2022_039***

Field : Material science, Mechanics and Fluids, Physics, Optics, Chemistry, Physical chemistry and Chemical Engineering

Subfield: near-surface hydrodynamics, lubrication, elastohydrodynamics

ParisTech School: ESPCI Paris - PSL
Research team: Interfacial dynamics of soft matter
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location: Paris
Lab website:https://www.gulliver.espci.fr/

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: MCGRAW Joshua joshua.mcgraw@espci.fr
Advisor 2: SALEZ Thomas thomas.salez@cnrs.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: If a particle moves toward a surface in a fluid medium, it forces the fluid to escape from the gap between the particle and the surface. Through the Stokes equations of hydrodynamics, the particle's motion creates a pressure field that may deform a neighbouring soft surface, which in turn can hugely influence the particle motion. This coupling is the domain of elastohydrodynamics (EHD). A relatively unexplored topic can be identified if, additionally, the surface is a porous one. Soft, porous materials are present on a diverse set of surfaces, from skeletal articulations and blood vessels, to drug delivery applications where hydrogel materials are common. The diffusion and hydrodynamics of both liquids and particles (e.g. colloid or macromolecule) near such materials is largely unexplored. This lack of investigation is due to the complexity of performing model experiments. In this thesis, fluid and particle motions near soft, porous media will be investigated by experiments based on a poro-elastohydrodynamic coupling. Both macroscopically imposed motion and thermal agitation being used as the main stimulus in advanced, atomic force microscopy (AFM) experiments with simultaneous interferometric optical measurements. The work will give rise to

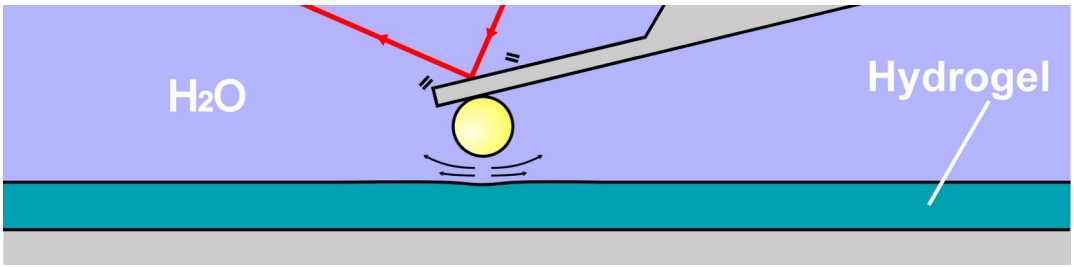
ultimately noninvasive methods to probe extremely delicate, soft and porous materials. Highly motivated students are warmly invited to make contact.

Required background of the student: Soft condensed matter, hydrodynamics, polymers, physics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. https://doi.org/10.1073/pnas.1525462113
2. https://doi.org/10.1017/S0022112010006555
3. https://doi.org/10.1103/PhysRevLett.109.128303
4.
5.

Illustrations :



ParisTech

Arts et Métiers Sciences et Technologies

TITLE: INSTABILITIES IN THE VANELESS DIFFUSER OF A CENTRIFUGAL PUMP

Topic number : ***2022_040***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: A. Dazin (Arts et Métiers), F. Romanò (Arts et Métiers), G Bois (Arts et Métiers)
Research lab: LMFL - Laboratoire de mécanique des fluides de Lille
Lab location: Lille
Lab website:https://lmfl.cnrs.fr/en/home/

Contact point for this topic: Arts et Métiers

Advisor 1: DAZIN Antoine antoine.dazin@ensam.eu
Advisor 2: ROMANO Francesco francesco.romano@ensam.eu
Advisor 3: BOIS Gérard gerard.bois@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Rotating flows in centrifugal pumps operating at partial flow rates could experience unsteady phenomena (boundary layer detachment, rotating stall ...) leading to a decay of their operational performance (see figures in the attachment). The presence of static and rotating parts, with a typically complex geometry, induces a complex base flow and makes difficult to predict and characterize these flow unsteadiness. Such phenomena become even more complex when a leakage flow is considered between the rotating and the static part of the pump. In this project the flow in the vaneless diffuser is considered, with the aim to investigate how the instabilities develop in the diffuser upon a change of the flow rate and the leakage characteristics. Both, numerical simulations and experiments will be carried out in this project.

Required background of the student: Education in Fluid mechanics, Physics, Applied Mathematics. Good knowledge of fluid mechanics and an interest for numerical and/or experimental methods. Good knowledge of oral and written English is required. Knowing a programming language (Python, C, Fortran) would be a plus.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Dazin, A., et al. High-speed stereoscopic PIV study of rotating instabilities in a radial vaneless diffuser. Experiments in fluids, 2011, 51.1: 83-93.

2. Heng, Y. G., Dazin, A., Ouarzazi, M. N., & Si, Q. R. (2016, November). Experimental study and theoretical analysis of the rotating stall in a vaneless diffuser of radial flow pump. In IOP Conference Series: Earth and Environmental Science (Vol. 49, No. 3, p. 032006). IOP Publishing.

3. Heng, Y., Dazin, A., Ouarzazi, M. N., & Si, Q. (2018). A study of rotating stall in a vaneless diffuser of radial flow pump. Journal of Hydraulic Research, 56(4), 494-504.

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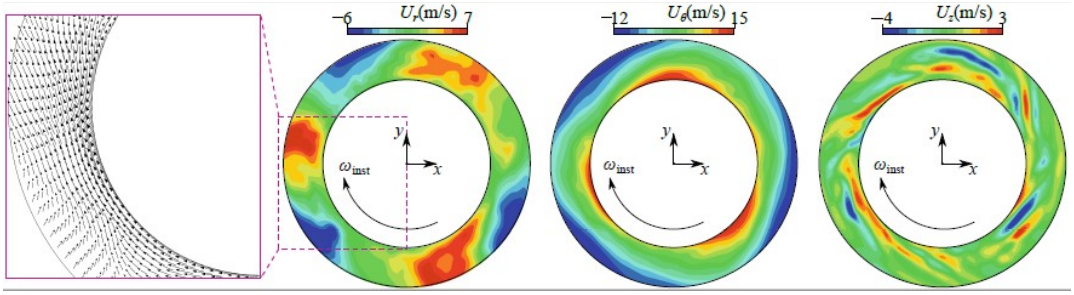
Illustrations :



ParisTech

Arts et Métiers

TITLE: INNOVATIVE DESIGN FOR ADDITIVE MANUFACTURING THROUGH KNOWLEDGE MANAGEMENT AND ARTIFICIAL INTELLIGENCE

Topic number : ***2022_041***

Field : Design, Industrialization, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Siadat Ali Ali.SIADAT@ensam.eu
Advisor 2: Hassan Alaa alaa.hassan@univ-lorraine.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Additive manufacturing (AM) offers significant opportunities for product innovation in many fields . The Design for Additive Manufacturing (DfAM) approach could be considered as a guideline for the design team in the early phase of the product development process . However, AM is becoming a data-intensive activity and the design of a new product can be facilitated by using previous knowledge from successful projects and the literature. This relevant knowledge is not easy to find or reuse. In this context, Artificial Intelligence (AI) is increasingly involved in the decision-makings throughout the stages of AM product development . AI techniques like Machine Learning (ML) is able to assist practitioners in product design, pre-manufacturing planning, and product quality assessment and control . The theory of inventive problem solving methodology (TRIZ) is a well-established accelerator to support problem solving by linking specific engineering problems and solutions to general patterns and laws . TRIZ method can be coupled with a well-structured knowledge base (KB) and ML algorithms in order to build a DfAM support system that helps the engineers in finding the most suitable rules and constraint-solving principles to fully exploit the potential of AM.
The main objectives of the proposal are:
1. Development of a KB system in order to capture and structure the

DfAM principles and knowledge. Web Ontology Language (OWL) or System Modelling Language (SysML) could be used.
2. Integrating the TRIZ inventive principles into the KB system supported by ML algorithms in order to build DfAM support system. AI could be used to map the problem space to the solution space and to retrieve the relevant information.

Required background of the student: The candidate must have a master degree in industrial, systems or informatics engineering. Skills in programming and Artificial Intelligence will be appreciated.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. T. J. Hagedorn, S. Krishnamurty, and I. R. Grosse, “A Knowledge-Based Method for Innovative Design for Additive Manufacturing Supported by Modular Ontologies,” J. Comput. Inf. Sci. Eng., vol. 18, no. 2, pp. 1–12, 2018.
2. S. Kadkhoda-Ahmadi, A. Hassan, and E. Asadollahi-Yazdi, “Process and resource selection methodology in design for additive manufacturing,” Int. J. Adv. Manuf. Technol., vol. 104, no. 5–8, pp. 2013–2029, 2019.
3. C. Liu, W. Tian, and C. Kan, “When AI meets additive manufacturing: Challenges and emerging opportunities for human-centered products development,” J. Manuf. Syst., vol. 64, no. May, pp. 648–656, 2022.
4. C. Wang, X. P. Tan, S. B. Tor, and C. S. Lim, “Machine learning in additive manufacturing: State-of-the-art and perspectives,” Addit. Manuf., vol. 36, no. January, p. 101538, 2020.
5. N. Kretzschmar and S. Chekurov, “The applicability of the 40 TRIZ principles in design for additive manufacturing,” Ann. DAAAM Proc. Int. DAAAM Symp., vol. 29, no. 1, pp. 888–893, 2018.

Illustrations :

Research Topic for the ParisTech/CSC PhD Program

Subfield: Industrial Engineering, Information Engineering

ParisTech School: Arts et Métiers ParisTech campus de Metz

Title: Innovative Design for Additive Manufacturing through Knowledge Management and Artificial Intelligence

Advisors: Pr. Ali SIADAT ali.siadat@ensam.eu
Dr. Alaa HASSAN alaa.hassan@univ-lorraine.fr

Short description of possible research topics for a PhD:

Additive manufacturing (AM) offers significant opportunities for product innovation in many fields [1]. The Design for Additive Manufacturing (DfAM) approach could be considered as a guideline for the design team in the early phase of the product development process [2]. However, AM is becoming a data-intensive activity and the design of a new product can be facilitated by using previous knowledge from successful projects and the literature. This relevant knowledge is not easy to find or reuse. In this context, Artificial Intelligence (AI) is increasingly involved in the decision-makings throughout the stages of AM product development [3]. AI techniques like Machine Learning (ML) is able to assist practitioners in product design, pre-manufacturing planning, and product quality assessment and control [4]. The theory of inventive problem solving methodology (TRIZ) is a well-established accelerator to support problem solving by linking specific engineering problems and solutions to general patterns and laws [5]. TRIZ method can be coupled with a well-structured knowledge base (KB) and ML algorithms in order to build a DfAM support system that helps the engineers in finding the most suitable rules and constraint-solving principles to fully exploit the potential of AM.
The main objectives of the proposal are:

1. Development of a KB system in order to capture and structure the DfAM principles and knowledge. Web Ontology Language (OWL) or System Modelling Language (SysML) could be used.
2. Integrating the TRIZ inventive principles into the KB system supported by ML algorithms in order to build DfAM support system. AI could be used to map the problem space to the solution space and to retrieve the relevant information.

Required background of the student:

The candidate must have a master degree in industrial, systems or informatics engineering. Skills in programming and Artificial Intelligence will be appreciated.

A list of 5 (max.) representative publications of the group:

[1] T. J. Hagedorn, S. Krishnamurty, and I. R. Grosse, “A Knowledge-Based Method for Innovative Design for Additive Manufacturing Supported by Modular Ontologies,” J. Comput. Inf. Sci. Eng., vol. 18, no. 2, pp. 1–12, 2018.

[2] S. Kadkhoda-Ahmadi, A. Hassan, and E. Asadollahi-Yazdi, “Process and resource selection methodology in design for additive manufacturing,” Int. J. Adv. Manuf. Technol., vol. 104, no. 5–8, pp. 2013–2029, 2019.

[3] C. Liu, W. Tian, and C. Kan, “When AI meets additive manufacturing: Challenges and emerging opportunities for human-centered products development,” J. Manuf. Syst., vol. 64, no. May, pp. 648–656, 2022.

[4] C. Wang, X. P. Tan, S. B. Tor, and C. S. Lim, “Machine learning in additive manufacturing: State-of-the-art and perspectives,” Addit. Manuf., vol. 36, no. January, p. 101538, 2020.

[5] N. Kretzschmar and S. Chekurov, “The applicability of the 40 TRIZ principles in design for additive manufacturing,” Ann. DAAAM Proc. Int. DAAAM Symp., vol. 29, no. 1, pp. 888–893, 2018.

ParisTech

TITLE: STABILITY OF DIKES BUILT WITH LIME-TREATED SOILS UNDER MARINE LOADING

Topic number : ***2022_042***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Ecole des Ponts ParisTech
Research team:
Research lab: Laboratoire NAVIER (mécanique, physique des matériaux et des structures, géotechnique)
Lab location: Champs-sur-Marne
Lab website:https://navier-lab.fr

Contact point for this topic: Ecole des Ponts ParisTech

Advisor 1: CUI Yujun yu-jun.cui@enpc.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Under tidal loading, sea dikes may present the stability problem (sliding, subsidence) under the effects of internal erosion, pore overpressure, drying/wetting cycles, salt dissolution/precipitation, etc. In Zi Ying's (2021) thesis, the effect of drying/wetting cycles on the stiffness (shear modulus) of a lime-treated silty soil (Les Salin-de-Giraud) was investigated through the variation of suction and microstructure, and the effect of dissolution/precipitation on osmotic suction and matrix suction was investigated through the measurement of electrical conductivity and microstructure. The focus was on the ionic interaction between hydrated lime and seawater. The effect of salinity on compressibility was also discussed. In contrast, the shear behavior of lime-treated soil in a saline environment has been little investigated.
In order to address the stability problem of sea dikes in lime-treated soils, it is proposed to study the mechanical behavior under the effects of salinity and internal erosion, with emphasis on the variation of the microstructure. For investigating the effect of salinity,
three to four salinities including the initial salinity and the salinity corresponding to seawater, and a lime dosage of 2% (dosage adopted in the Digue 2020 project), are selected to prepare the compacted lime

treated soil. After 90 days of curing, the soil samples will be tested in triaxial celles to determine the shear behavior (modulus, cohesion, friction angle). For the investigating the effect of internal erosion After the preparation of the samples by compaction and after 90 days of curing, the samples will undergo different hydraulic cyclic loadings and triaxial testing. Based on the experimental results, a constitutive model will be developed to describe the mechanical behavior of lime-treated soils subjected to marine loading.

Required background of the student: Soil mechanics, mechanics of porous media, experience in laboratory testing

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. YING Z., DUC M., CUI Y.J, BENAHMED N. 2021. Salinity Assessment for Salted Soil Considering Both Dissolved and Precipitated Salts. Geotechnical Testing Journal 44 (1), 130-147.
2. YING Z., CUI Y.J, BENAHMED N., DUC M. 2021. Salinity effect on the compaction behaviour, matric suction, stiffness and microstructure of a silty soil. Journal of Rock Mechanics and Geotechnical Engineering 13, 855-863.
3. YING Z., BENAHMED N., CUI Y.J, DUC M. 2022. Wetting-drying cycle effect on the compressibility of lime-treated soil accounting for wetting fluid nature and aggregate size. Engineering Geology 307, 106778.
4. YING Z., CUI Y.J, BENAHMED N., DUC M. 2022. Drying effect on the microstructure of compacted salted silt. Géotechnique, online.
5. YING Z., CUI Y.J, DUC M., BENAHMED N. 2022. Effect of salt solution on the optimum lime contents of bentonite and silt, Acta Geotechnica, Online.

Illustrations :

ParisTech

ESPCI PARIS PSL

TITLE: HIGH TEMPERATURE SUPERCONDUCTORS FOR SINGLE PHOTON DETECTION

Topic number : ***2022_043***

Field : Physics, Optics, Material science, Mechanics and Fluids, Information and Communication Science and Technology

Subfield: Superconductivity

ParisTech School: ESPCI Paris - PSL
Research team: Phasme http://www.phasme.espci.fr
Research lab: LPEM - Laboratoire Physique et d'études des matériaux
Lab location: Paris
Lab website:http://www.espci.fr

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: FEUILLET-PALMA Cheryl cheryl.palma@espci.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD:
Superconducting Single Photon Detectors (SSPD) are central element for numerous applications including time-of-time imaging and quantum cryptography systems. They consist of superconducting nanowires biased near their critical current. A (visible or near IR) photon absorption creates a hotspot that is converted into a measurable voltage pulse. Low-Tc SSPD have the best performances at 4K but need energy-consuming 4K cryogenics.
We propose to fabricate high-Tc SSPD with YBa2Cu3O7 and Bi2Sr2CaCu2O8+x that will operate at higher temperature (40K) with simplified cryogenics and at higher frequency, and to investigate the far-from-being-understood microscopic mechanism leading to hotspot formation. We will perform global transport measurements on a biased YBCO and field effect tunable BiSCCO nanowires. We will explore the phase diagram influence on the development of a hotspot. This will give information about the physics of the systems, and will help improving high Tc SSPDs.

Required background of the student: Knowledge and skills required: Motivated student with a solid

background in fundamental physics (Master 2 in condensed matter, quantum physics, materials, nanosciences...) and attracted by experimental physics.
Techniques used: electronic transport, nano-fabrication (optical and electronic lithography, etching, deposition...), optics (optical fibre, optical cavity...), microwave instrumentation, cryogenics.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Quantized conductance in a onedimensional ballistic oxide nanodevice

A. Jouan, G. Singh, E. Lesne, D. C. Vaz, M. Bibes, A. Barthélémy, C. Ulysse, D. Stornaiuolo, M. Salluzzo, S. Hurand, J. Lesueur, C. Feuillet-Palma, N. Bergeal, Nature Electronics (2020)

2. Dynamic properties of high-Tc superconducting nano-junctions made with a focused helium ion beam F. Couëdo, P. Amari, C. Feuillet-Palma, C. Ulysse, Y. Kumar Srivastava, R.Singh, N. Bergeal, and J. Lesueur Scientific Report (2020)

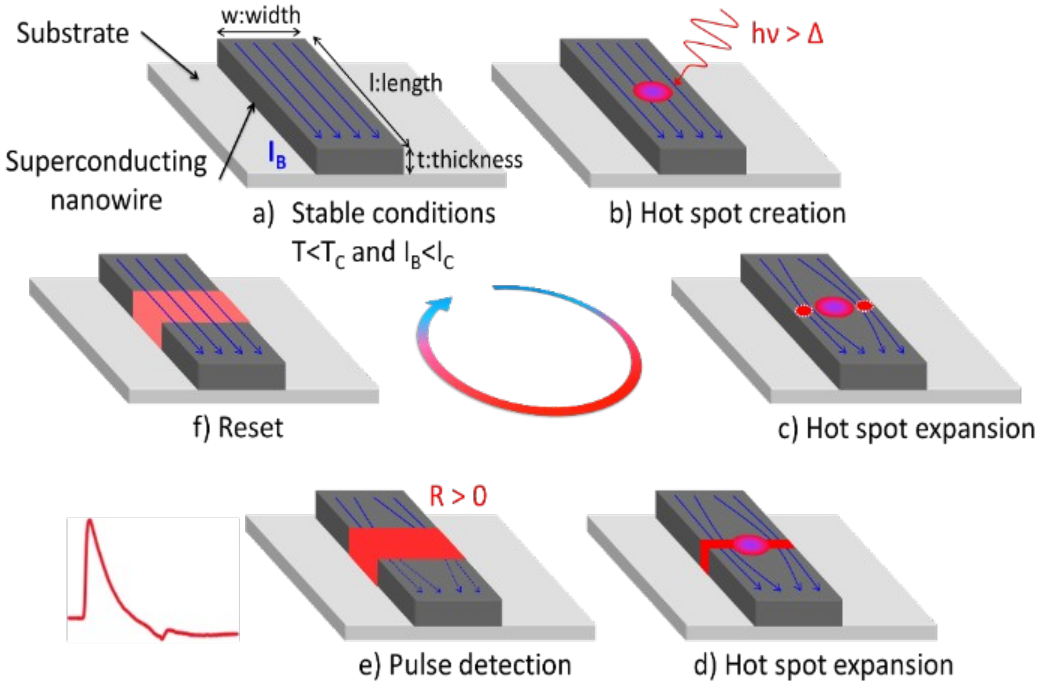
3. High-Tc superconducting antenna for highly-sensitive microwave magnetometry

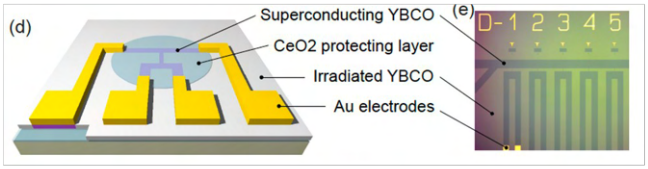
F. Couëdo, E. Recoba Pawlowski, J. Kermorvant, D. Crété, Y. Lemaître, B. Marcilhac, C. Ulysse, C. Feuillet-Palma, N. Bergeal, and J. Lesueur Applied Physics Letter 14, 192602 (2019)

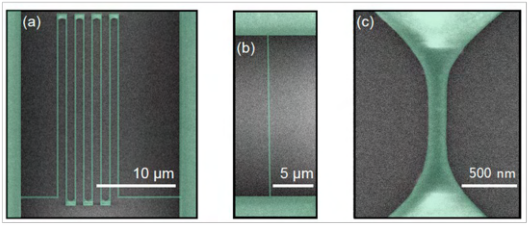
4. Ion irradiated YBa2Cu3O7 nano-meanders for superconducting single photon detectors. P. Amari, C. Feuillet-Palma, A. Jouan, F. Couedo, N. Bourlet, E. Géron, M. Malnou, A. Sharafiev, J. Lesueur & N. Bergeal Supercond. Sci. Technol. 31, 015019 (2018).

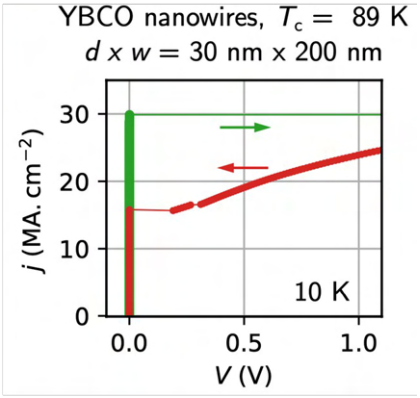
5. Shiba bound states across the mobility edge in doped InAs nanowires A. Assouline, C. Feuillet-Palma, A. Zimmers, H. Aubin, M. Aprili, J.C. Harmand Physical Review Letters 119 (9), 097701A (2017)

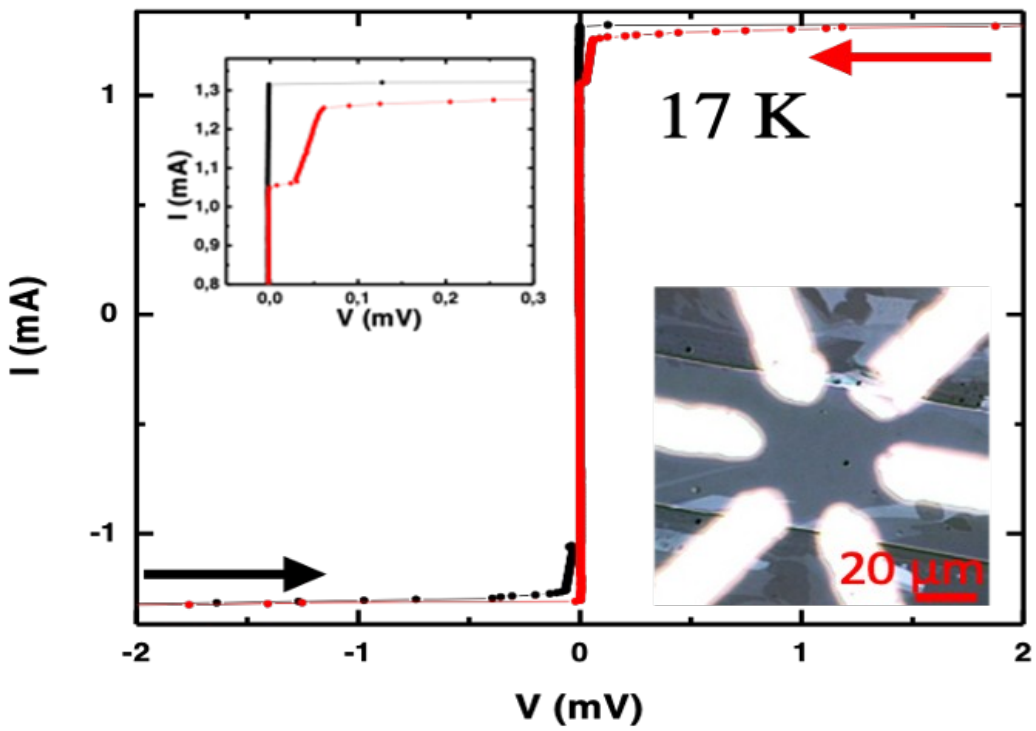
Illustrations :


Substrate
w:width
l:length
t:thickness
I_B
Superconducting nanowire
a) Stable conditions
$T<T_C$ and $I_B<I_C$
hv > Δ
b) Hot spot creation
c) Hot spot expansion
f) Reset
R > 0
e) Pulse detection
d) Hot spot expansion


(d)
Superconducting YBCO
CeO2 protecting layer
Irradiated YBCO
Au electrodes
(e)
0 1 2 3 4 5


(a)
10 µm
(b)
5 µm
(c)
500 nm


YBCO nanowires, T_c = 89 K
d x w = 30 nm x 200 nm
j (MA. cm^{-2})
30
20
10
0
10 K
0.0
0.5
1.0
V (V)


17 K
I (mA)
V (mV)
20 µm
1
0
-1
-2
-1
0
1
2
1,3
1,2
1,1
1,0
0,9
0,8
0,0
0,1
0,2
0,3

Cheryl Feuillet-Palma,
cheryl.palma@espci.fr

High temperature superconductors for single photon detection

Superconducting single photon detector (SSPD) technology has emerged as a building block for many applications, including quantum cryptography, quantum optics and computing, and space-to-Earth communication [1]. Such devices consist of a long superconducting wire (typically 100 nm wide and several microns long) biased just below the critical current. When an incident photon is absorbed by the wire, it generates a hot spot that locally destroys the superconductivity and creates a resistive region [2] (Figure 1). This phenomenon induces a voltage pulse (typical duration ~5ns) which is used to detect the arrival of a single photon, before the wire returns to its initial state.

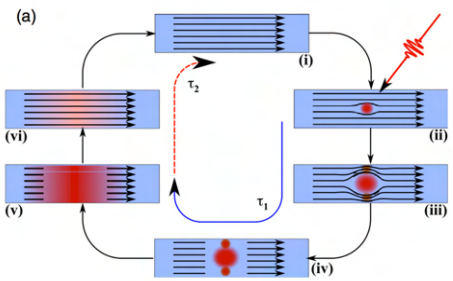


Figure 1: SSPD operation principle[3] A superconducting nanowire is biased just below its critical current (i). When a photon (visible or Infrared wavelength) with energy much higher than the superconducting gap is absorbed, it breaks Cooper pairs and creates a so-called hotspot (ii). This normal region deviates the supercurrent that spreads over the edges of the wire until exceeding the critical current density (iii). Then the nanowire locally transits to its resistive state (iv) that generates a voltage pulse.

For the last decade, single photon detection based on this principle has been developed mainly with Nb and NbN nanowires, operating at the temperature of liquid Helium (4K). However, the speed of these devices is limited by the reset time of the superconducting state which is intrinsically linked to the electron-phonon diffusion time in the superconductor. In addition, the operating temperature constraint considerably hinders the implementation of this technology in practical applications. In this context, the use of high-temperature superconducting nanowires has two main advantages: the critical temperature of the superconducting state is higher and the electron-phonon diffusion time is smaller than the times of current SSPDs, which should allow for an increase in operating speed.

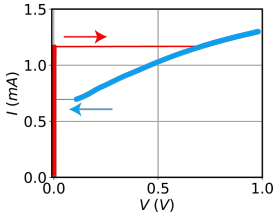


Figure 2 : Hysteretic I-V curve of 30 nm thick, 100 nm wide YBCO nanowire at 5.5 K,

The PhD project aims to develop a new kind of ultra-fast superconducting nanowire single-photon detectors operating around 40 K. To do so, **SSPDs will be made of two high temperature superconductors (i) $YBa_2Cu_3O_7$ (YBCO) and (ii) $Bi_2Sr_2CaCu_2O_{8+x}$ (BiSCCO).**

Using commercial high-temperature critical film, we have developed a powerful technique to structures High-Temperature Superconducting films at the nanoscale combining advanced electron-beam lithography with ion irradiation technique. Recently, we measured the largest voltage switch reported so far for HTS nanowires (~1 V), which is comparable to low Tc based meanders response. We will reduce further the nanowire cross-section to optimize the energy transfer from the incident photon to the nanowire. We will work with our commercial thin film supplier Ceraco to get high quality capped YBCO films with thickness well below 30 nm. Nanofabrication will be carried out using an electron beam lithography available at ESPCI Paris.

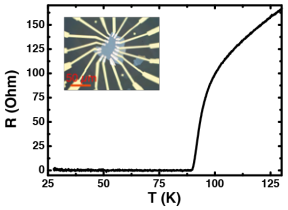


Figure 2 : Four-probe resistance measurement of a superconducting 50μm-wide hBN-capped 2D BiSCCO crystal as a function of temperature. Inset: optical image of the device.

In parallel, we will structure a high-temperature critical film monolayer in BISCCO whose superconductivity can be controlled by an electric field effect. We will study two types of BiSCCO devices. Either by combining both Van Der Waals heterostructure and anodic bonding technique (see figure 3). Or by combining anodic bonding on a pre-structured substrate (see figure 4 inset), we will produce nanowires whose critical temperature can be controlled by field effect. The device will be electrically characterized at low frequency (see I-V curves figure 3), cryogenic temperatures, under magnetic field and in the presence of radio frequency excitation for different dopings. Then, the optical

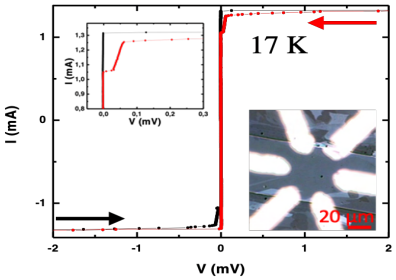


Figure 3 : Current-voltage characteristic at 17K (top insert, zoom in the switching), showing hysteresis and voltage jump necessary to show single-photon detection of 55 µm wide band of a 4.5 nm thick BiSCCO film (bottom insert)

Cheryl Feuillet-Palma,
cheryl.palma@espci.fr

excitation of the device using an optical fibre and a laser will allow the study of the response of the nanowire to photons, in the presence of a magnetic field. This new generation of device offers a unique opportunity to explore the physics of field-doped high-temperature superconductor-based nanowires as a single photon detector.

Knowledge and skills required: Motivated student with a solid background in fundamental physics (Master 2 in condensed matter, quantum physics, materials, nanosciences...) and attracted by experimental physics.
Techniques used: electronic transport, nano-fabrication (optical and electronic lithography, etching, deposition...), optics (optical fibre, optical cavity...), microwave instrumentation, cryogenics.

[1] Nature Photon. 3 696-705 (2009) [2] Supercond. Sci. Technol (2012) [3] Appl. Phys. Lett. 79, 705-707 (2001).

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: GRAPH-BASED UNBOUNDED CONSTRAINED MODELS SEARCH FOR HIGH-LEVEL LOGICAL REASONING

Topic number : ***2022_045***

Field : Information and Communication Science and Technology, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Aix-en-Provence
Lab website:lispen.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: KLEINER Mathias mathias.kleiner@ensam.eu
Advisor 2: PERNOT Jean-Philippe Jean-Philippe.Pernot@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The project is a fundamental research proposal involving algorithms and software

development. The project aims at providing an original reasoning approach for hard
combinatorial problems based on the generation of finite graphs under a set of
structural constraints.
More precisely, we are interested in problems where knowledge is represented in the
form of an object-oriented model with additional constraints expressed in first-order
predicate logic (for instance, metamodels conforming to OMG's MOF and their
associated OCL constraints). In this context, a classical problem is to be able to
generate an instance of the object model which satisfies all the constraints. For instance, it can be
used to automatically explore cyber-physical systems engineering alternatives given a loosely de-

fined partial solution.
Existing approaches mostly rely on the mapping between the model and its
constraints to a lower-level constraint programming paradigm (e.g. SAT, CSP) where
resolution (e.g. constraint-based solving) is achieved. However the translations
induce drawbacks such as the loss of structure knowledge about the problem, they require to
bound the solutions potential number of elements (since real first-order logic is rarely
supported by current solvers), and some constraints are hard (or even impossible) to
translate efficiently.
The main idea behind this project is that resolution at a graph-level, using graph
generation techniques, may allow for a more efficient resolution. Indeed it is then
possible to exploit the structure of the object-model and its solutions to guide the
search more efficiently (for instance graph-based heuristics), discard unsatisfiable
partial solutions that could not be detected otherwise (for instance graph

isomorphisms), and it is not necessary to bound the number of solution elements (by
generating structures of a priori unknown size). On a more practical level, another
benefit of the approach is that it reduces the gap between the original knowledge
representation and the reasoner paradigms, hence allowing for a more integrated use
of the solver in a software chain (e.g. reverse mapping of the solution, understandable
structure-based explanations, etc.). Advances in the theoretical aspects, novel
algorithms, usecases and integration of a free software library in a model-based
software environment (such as Eclipse Modelling Framework) are among the expected
outputs of the project.
The proposed approach will be validated on multiple case studies ranging from litterature toy prob-
lems to more complex applications (cyber-physical systems engineering, 3D geometry, natural lan-
guage parsing and texts generation, etc.)

Required background of the student: Computer science, excellent programming skills, combinatorial algorithms,
constraint programming

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Laurent Hénocque, Mathias Kleiner, Nicolas Prcovic, “Advances in polytime isomorph elimination for con-
figuration”, Principles and Practice of Constraint Programming-CP 2005, p. 301-313, Springer, 2005.
2. Mathias Kleiner, Marcos Didonet Del Fabro, “A generic approach to model generation operations”, Journal of
Systems and Software, p 136-155, Elsevier, 2018.
3. Hu H., Kleiner M., Pernot J-P., “Over-constraints detection and resolution in geometric equation systems”,
Computer-Aided Design (2017), vol. 90, pp. 84-94.
4. Gilles Gouaty, Lincong Fang, Dominique Michelucci, Marc Daniel, Jean-Philippe Pernot, Romain Raffin, San-
drine Lanquetin, Marc Neveu, “Variational geometric modeling with black box constraints and DAGs”, Com-
puter-Aided Design 75, p. 1-12, 2016
5.

Illustrations :

TITLE: HOW ADAPT RECONFIGURABLE PRODUCTION SYSTEMS TO PRODUCT VARIABILITY AND IMPROVE SCALABILITY AND REUSABILITY OF RMS

Topic number : ***2022_046***

Field : Design, Industrialization, Design, Industrialization, Mathematics and their applications

Subfield:

ParisTech School: Arts et Métiers
Research team: Paul STIEF, Jean-Yves DANTAN, Ali SIADAT
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:https://lcfc.ensam.eu/lcfc-accueil-119817.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: Dantan Jean-Yves jean-yves.dantan@ensam.eu
Advisor 2: Stief Paul paul.stief@ensam.eu
Advisor 3: SIADAT Ali ali.siadat@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Today's industrial environment is still marked by an ongoing trend towards more customised products. In addition, the past years have shown an increasing instability of the worldwide economy due to an accumulation of catastrophes and crises. This very fluctuating ecosystem confronts industrial production companies with serious challenges regarding the outset of their production systems. Lot sizes are decreasing and become instable, as well as product demand in general. Therefore, achieving a quick return of invest with single product manufacturing and assembly lines becomes harder. In a co-evolution approach, the challenge is then to orient either the product evolutions to better fit the production system abilities or to evolve the production system towards a better coverage of product variety needs. To achieve this, the thesis objective is to allow precise knowledge of production system abilities to be gathered concerning its actual state and future states (evolution). In this context, it is possible to claim that scalability is one specific form of flexibility and reconfigurability. And scalability property of reconfigurability has unexplored potential making it a major topic of investigation. Although it is proposed to incorporate scalability in RMS, the question of how to actually realise it, needs investigation. There is a lack of research work

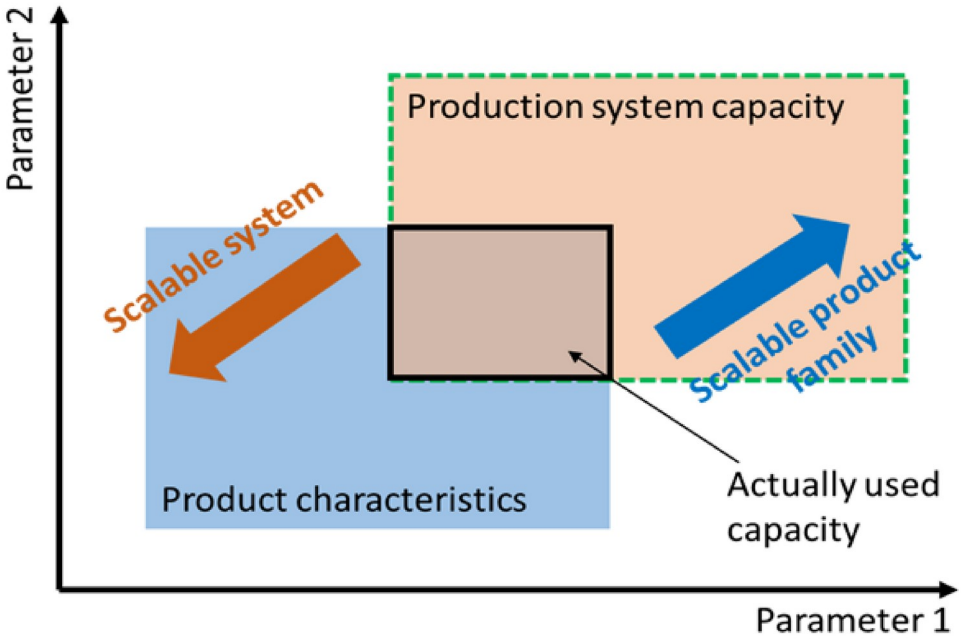
concerning the evaluation of the production system capacities to be adaptable. The research question is how to achieve a consistency between the adaptability needs induced by product variety and the adaptability capacity provided by the production system by improving scalability and reusability of RMS.

Required background of the student: Mechanical Engineering, Strong technical and technological background, at least some basic industrial background welcome

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Stief, P., A. Etienne, J.-Y. Dantan, and A. Siadat. 2022. 'A Methodology for Production System Design Driven by Product Modelling and Analysis – Application in the Automotive Industry'. International Journal of Production Research, February, 1–17. https://doi.org/10.1080/00207543.2022.2036382.
2. Stief, P., J.-Y. Dantan, A. Etienne, A. Siadat, and G. Burgat. 2020. 'Product Design Improvement by a New Similarity-Index-Based Approach in the Context of Reconfigurable Assembly Processes'. Journal of Engineering Design 31 (6): 349–77. https://doi.org/10.1080/09544828.2020.1748181.
3. Stief, P., J.-Y. Dantan, A. Etienne, A. Siadat, and G. Burgat. 2019. 'New Product Similarity Index Development with Application to an Assembly System Typology Selection'. In Procedia CIRP, 81:1077–82. Ljubljana: Elsevier Science. https://doi.org/10.1016/j.procir.2019.03.256.
4. T. Tolio et al., 'SPECIES—Co-evolution of products, processes and production systems', CIRP Annals - Manufacturing Technology, vol. 59, no. 2, pp. 672–693, Jan. 2010, doi: 10.1016/j.cirp.2010.05.008.
5. Y. Koren, X. Gu, and Guo W., 'Reconfigurable manufacturing systems: Principles, design, and future trends', Front. Mech. Eng., vol. 13, no. 2, pp. 121–136, Jan. 2018, doi: 10.1007/s11465-018-0483-0.

Illustrations :


Parameter 2
Production system capacity
Scalable system
Scalable product family
Product characteristics
Actually used capacity
Parameter 1

How adapt reconfigurable production systems to product variability and improve scalability and reusability of RMS

Context: Today's industrial environment is still marked by an ongoing trend towards more customised products. In addition, the past years have shown an increasing instability of the worldwide economy due to an accumulation of catastrophes and crises. This very fluctuating ecosystem confronts industrial production companies with serious challenges regarding the outset of their production systems. Lot sizes are decreasing and become instable, as well as product demand in general. Therefore, achieving a quick return of invest with single product manufacturing and assembly lines becomes harder.

On the side of product development, modular design approaches, delayed product development and design for assembly/manufacturing have been developed to manage product variety and control its impact on the production system. These approaches are seconded by a large amount of similarity indices and similarity analysis methods. On the side of the production system, the paradigms of agility, reconfigurability and flexibility have been introduced to manage the system adaptability. The last evolution consists on combining product and production system by co-evolution approaches.

Scientific issue: For co-evolution, product evolution and production system evolution are put into parallel to anticipate changes of both [1]–[4]. Also, reconfigurable systems are outset to respond exactly to the adaptability need of a product family [5]–[7]. Little research has been carried out to characterise the abilities of a production system in a global way [8]–[10]. Figure 1 illustrates different problematics linked to these issues: The production system on one hand is not capable to be adapted to the entire product variety, but on the other hand it has unused abilities. In a co-evolution approach, the challenge is then to orient either the product evolutions to better fit the production system abilities or to evolve the production system towards a better coverage of product variety needs.

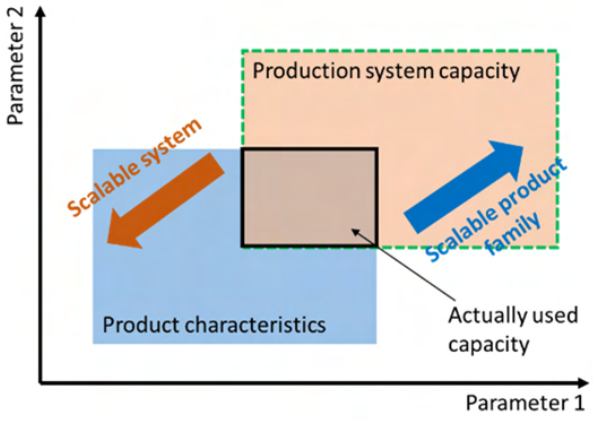


Figure 1. Production system ability and product design needs

To achieve this, the thesis objective is to allow precise knowledge of production system abilities to be gathered concerning its actual state and future states (evolution). In this context, it is possible to claim that scalability is one specific form of flexibility and reconfigurability. And scalability property of reconfigurability has unexplored potential making it a major topic of investigation [11]. Although it is proposed to incorporate scalability in RMS, the question of how to actually realise it, needs investigation.

To conclude, there is a lack of research work concerning the evaluation of the production system capacities to be adaptable. The research question is ***how to achieve a consistency between the adaptability needs induced by product variety and the adaptability capacity provided by the production system by improving scalability and reusability of RMS.***

Thesis perimeter (to refine by the candidate):

- Locate the research work in co-evolution and/or reconfigurability research streams
- Identify work done on the reconfiguration/adaptation capacities of the production system
- Determine the exact scope of the thesis (assembly/ manufacturing/…)
- Identify criteria defining the scalability of a production system
- Map product variety characteristics – production system abilities
- Develop an exhaustive and applicable methodology considering co-evolution (a practical, methodology oriented work is more expected than mathematical modelling and operations research)

[1] T. Tolio *et al.*, 'SPECIES—Co-evolution of products, processes and production systems', *CIRP Annals - Manufacturing Technology*, vol. 59, no. 2, pp. 672–693, Jan. 2010, doi: 10.1016/j.cirp.2010.05.008.
[2] T. AlGeddawy and H. A. ElMaraghy, 'A model for co-evolution in manufacturing based on biological analogy', *International Journal of Production Research*, vol. 49, no. 15, pp. 4415–4435, Jan. 2011, doi: 10.1080/00207543.2010.497780.
[3] H. A. ElMaraghy and T. AlGeddawy, 'Co-evolution of products and manufacturing capabilities and application in auto-parts assembly', *Flex Serv Manuf J*, vol. 24, no. 2, pp. 142–170, Jan. 2012, doi: 10.1007/s10696-011-9088-1.
[4] A. Bryan, J. Ko, S. J. Hu, and Y. Koren, 'Co-Evolution of Product Families and Assembly Systems', *CIRP Annals - Manufacturing Technology*, vol. 56, no. 1, pp. 41–44, Jan. 2007, doi: 10.1016/j.cirp.2007.05.012.
[5] Y. Koren, X. Gu, and Guo W., 'Reconfigurable manufacturing systems: Principles, design, and future trends', *Front. Mech. Eng.*, vol. 13, no. 2, pp. 121–136, Jan. 2018, doi: 10.1007/s11465-018-0483-0.
[6] Y. Koren and M. Shpitalni, 'Design of reconfigurable manufacturing systems', *Journal of Manufacturing Systems*, vol. 29, no. 4, pp. 130–141, Jan. 2010, doi: 10.1016/j.jmsy.2011.01.001.
[7] Y. Koren *et al.*, 'Reconfigurable Manufacturing Systems', *CIRP Annals - Manufacturing Technology*, vol. 48, no. 2, pp. 527–540, Jan. 1999, doi: 10.1016/S0007-8506(07)63232-6.
[8] A. M. Farid, 'Product Degrees of Freedom as Manufacturing System Reconfiguration Potential Measures', *Int. Trans. on Systems Science and Applications*, vol. 4, no. 3, pp. 227–242, Jan. 2008.
[9] A. M. Farid and D. C. McFarlane, 'Production degrees of freedom as manufacturing system reconfiguration potential measures', *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, vol. 222, no. 10, pp. 1301–1314, Jan. 2008, doi: 10.1243/09544054JEM1056.
[10] A. M. Farid and D. C. McFarlane, 'A Development of Degrees of Freedom for Manufacturing Systems', in *IMS'2006: 5th International Symposium on Intelligent Manufacturing Systems*, Jan. 2006.
[11] Putnik, G., A. Sluga, H. ElMaraghy, R. Teti, Y. Koren, T. Tolio, and B. Hon. 2013. 'Scalability in Manufacturing Systems Design and Operation: State-of-the-Art and Future Developments Roadmap'. CIRP Annals 62 (2): 751–74. https://doi.org/10.1016/j.cirp.2013.05.002.

Contact: Dr. Paul STIEF paul.stief@ensam.eu – Arts et Métiers Metz, 4 Rue Augustin Fresnel, 57078 METZ

TITLE: EXPERIMENTAL INVESTIGATION OF CAVITATION VS. DEGASSING PHENOMENA IN A SYMMETRICAL VENTURI CHANNEL

Topic number : ***2022_047***

Field : Energy, Processes, Environment Science and Technology, Sustainable Development, Geosciences, Physics, Optics

Subfield:

ParisTech School: Arts et Métiers
Research team: AéroHydrodynamique Physique
Research lab: LIFSE - Laboratoire Ingénierie des Fluides Systèmes Energétiques
Lab location: Paris
Lab website:HTTPS://LIFSE.ARTSETMETIERS.FR/

Contact point for this topic: Arts et Métiers

Advisor 1: RAVELET FLORENT florent.ravelet@ensam.eu
Advisor 2: DANLOS AMELIE amelie.danlos@ensam.eu
Advisor 3: PEREIRA MICHAEL michael.pereira@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The phenomenon of cavitation corresponds to a change of state of a fluid (vaporization: change from the liquid phase to vapor) operating when the pressure of the liquid drops below the vapor pressure of the liquid. Also, the presence of dissolved gases in liquids has long been known to increase the susceptibility of liquids to the occurrence of cavitation. Dissolved gases can be released after a pressure drop. This phenomenon is called degassing and it changes certain properties of the liquid such as density, surface tension and local temperature. Recently, the effect of a high rate of gas dissolved in fluids on developed cavitation has caught the attention of the scientific community .

A particular area of interest is fuels used in the aviation industry, which contain multiple types of dissolved gases due to their complex hydrocarbon nature. For example, during flights at high altitude (therefore low pressure), the phenomena of cavitation and degassing in kerosene become an issue and can cause instability in the operation of the engine. To study this in the laboratory, other substitute working fluids are being considered. In the vast majority of the literature on the subject,

cavitation has been studied for turbulent flows with water. The water/air flows are not very suitable, since the gas does not dissolve significantly.

In order to better understand the behavior of these instabilities and to control them, some studies have been carried out with water/CO_2 or silicone/air flows. In the latter, the dissolution of gas operates more. The idea of this thesis is therefore to study in detail, in a simple geometry (restriction type), cavitation and degassing with a fluid having a viscosity equivalent to kerosene. To our knowledge, there is a lack of scientific literature on the subject of fuel-like liquids in terms of cavitation dynamics.

The LIFSE laboratory has a test bench for the study of these phenomena. We are considering a test vein with a symmetrical Venturi type geometry for the study. Lately, we have focused on high viscosity fluids to study laminar cavitation . The results have mainly shown large differences in the behavior of the cavitation developed between a completely degassed working fluid and a fluid with a very high rate of dissolved air. We therefore propose to study the kinetics of degassing and recapture of air with oils with a viscosity close to kerosene. It would be interesting to highlight the characteristic times of gas absorption or degassing, as well as their dependence on the physico-chemical parameters intrinsic to the working fluid.

Tests will then be carried out in the hydrodynamic tunnel, infrastructure of the CONFLUENCE ® technological platform of the LIFSE laboratory (Arts & Métiers Institute of Technology). The metrology resources used for the experimental part are those of the laboratory, using innovated techniques. The dynamic metrology laboratory (LMD) will moreover obtain an undeniable technological support during measurement campaigns.
Several means of metrology can be employed, to provide the answers, over here include a non-exhaustive list:
- Characterization of the flow by PIV technique in resolved-time or with Stereo-PIV- LDV
- High-speed video recording
- Oxymeter probe

Required background of the student: engineering or physics degree

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Ravelet, F., Danlos, A., Bakir, F., Croci, K., Khelladi, S., & Sarraf, C. (2020). Development of Attached Cavitation at Very Low Reynolds

Numbers from Partial to Super-Cavitation. Applied Sciences, 10(20), 7350.
2. Tomov, P., Khelladi, S., Ravelet, F., Sarraf, C., Bakir, F., & Vertenoeuil, P. (2016). Experimental study of aerated cavitation in a horizontal venturi nozzle. Experimental Thermal and Fluid Science, 70, 85-95.
3. Croci, K., Ravelet, F., Danlos, A., Robinet, J. C., & Barast, L. (2019). Attached cavitation in laminar separations within a transition to unsteadiness. Physics of Fluids, 31(6), 063605.
4. Magne, T., Paridaens, R., Ravelet, F., Khelladi, S., Bakir, F., Tomov, P., & Pora, L. (2020). Effect of gas content on the cavitating and non-cavitating performance of an axial three-bladed inducer. Multiphase Science and Technology, 32(1).
5. Magne, T., Paridaens, R., Khelladi, S., Bakir, F., Tomov, P., & Pora, L. (2020). Experimental Study of the Hydraulic Performances of Two Three-Bladed Inducers in Water, Water With Dissolved CO2, and Jet Fuel. Journal of Fluids Engineering, 142(11).

Illustrations :

ParisTech

Arts et Métiers Institute of Technology

RESEARCH TOPIC FOR THE PARISTECH / CSC PHD PROGRAM

Field: Physics
Subfield: Fluid mechanics

Title:

Experimental investigation of Cavitation *vs.* Degassing phenomena in a symmetrical Venturi channel

ParisTech School: Arts et Métiers - Institute of Technology

Advisor(s) Name: Pr. Florent Ravelet
Dr. Amelie Danlos
Dr. Michaël Pereira

Advisor(s) Email:
florent.ravelet@ensam.eu
amelie.danlos@ensam.eu
michael.pereira@ensam.eu

Research group/Lab: Laboratory of Fluids Engineering and Energy Systems (LIFSE)
Lab location: 151 Boulevard de l'hôpital 75013 PARIS
Lab Website: https://lifse.artsetmetiers.fr

Short description of possible research topics for a PhD :

The phenomenon of cavitation corresponds to a change of state of a fluid (vaporization: change from the liquid phase to vapor) operating when the pressure of the liquid drops below the vapor pressure of the liquid. Also, the presence of dissolved gases in liquids has long been known to increase the susceptibility of liquids to the occurrence of cavitation. Dissolved gases can be released after a pressure drop. This phenomenon is called degassing and it changes certain properties of the liquid such as density, surface tension and local temperature. Recently, the effect of a high rate of gas dissolved in fluids on developed cavitation has caught the attention of the scientific community [2;3].

A particular area of interest is fuels used in the aviation industry, which contain multiple types of dissolved gases due to their complex hydrocarbon nature. For example, during flights at high altitude (therefore low pressure), the phenomena of cavitation and degassing in kerosene become an issue and can cause instability in the operation of the engine. To study this in the laboratory, other substitute working fluids are being considered. In the vast majority of the literature on the subject, cavitation has been studied for turbulent flows with water. The water/air flows are not very suitable, since the gas does not dissolve significantly.

In order to better understand the behavior of these instabilities and to control them, some studies have been carried out with water/CO2 [4;5] or silicone/air [1] flows. In the latter, the dissolution of gas operates more. The idea of this thesis is therefore to study in detail, in a simple geometry (restriction type), cavitation and degassing with a fluid having a viscosity equivalent to kerosene. To our knowledge, there is a lack of scientific literature on the subject of fuel-like liquids in terms of cavitation dynamics.

The LIFSE laboratory has a test bench for the study of these phenomena. We are considering a test vein with a symmetrical Venturi type geometry for the study. Lately, we have focused on high viscosity fluids to study laminar cavitation [1]. The results have mainly shown large differences in the behavior of the cavitation developed between a completely degassed working fluid and a fluid with a very high rate of dissolved air. We therefore propose to study the kinetics of degassing and recapture of air with oils with a viscosity close to kerosene. It would be interesting to highlight the characteristic times of gas absorption or degassing, as well as their dependence on the physico-chemical parameters intrinsic to the working fluid.

Tests will then be carried out in the hydrodynamic tunnel, infrastructure of the CONFLUENCE ® technological platform of the LIFSE laboratory (Arts & Métiers Institute of Technology). The metrology resources used for the experimental part are those of the laboratory, using innovated techniques. The dynamic metrology laboratory (LMD) will moreover obtain an undeniable technological support during measurement campaigns.

Several means of metrology can be employed, to provide the answers, over here include a non-exhaustive list:
- Characterization of the flow by PIV technique in resolved-time or with Stereo-PIV
- LDV
- High-speed video recording
- Oxymeter probe

Required background of the student:
Physics / Fluid Dynamics / Hydrodynamics / Cavitation / Experimental

A list of 5 (max.) representative publications of the group:

1) Ravelet, F., Danlos, A., Bakir, F., Croci, K., Khelladi, S., & Sarraf, C. (2020). Development of Attached Cavitation at Very Low Reynolds Numbers from Partial to Super-Cavitation. *Applied Sciences*, *10*(20), 7350.

2) Tomov, P., Khelladi, S., Ravelet, F., Sarraf, C., Bakir, F., & Vertenoeuil, P. (2016). Experimental study of aerated cavitation in a horizontal venturi nozzle. *Experimental Thermal and Fluid Science*, *70*, 85-95.

3) Croci, K., Ravelet, F., Danlos, A., Robinet, J. C., & Barast, L. (2019). Attached cavitation in laminar separations within a transition to unsteadiness. *Physics of Fluids*, *31*(6), 063605.

4) Magne, T., Paridaens, R., Ravelet, F., Khelladi, S., Bakir, F., Tomov, P., & Pora, L. (2020). Effect of gas content on the cavitating and non-cavitating performance of an axial three-bladed inducer. *Multiphase Science and Technology*, *32*(1).

5) Magne, T., Paridaens, R., Khelladi, S., Bakir, F., Tomov, P., & Pora, L. (2020). Experimental Study of the Hydraulic Performances of Two Three-Bladed Inducers in Water, Water With Dissolved CO2, and Jet Fuel. *Journal of Fluids Engineering*, *142*(11).

ParisTech

TITLE: CHARGE TRANPORT IN ORGANIC PHOTOVOLTAICS: FROM MODELING TO RATIONALE DESIGN

Topic number : ***2022_048***

Field : Energy, Processes, Chemistry, Physical chemistry and Chemical Engineering, Material science, Mechanics and Fluids

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Theoretical Chemistry and Modeling Team http://www.quanthic.fr
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:http://www.iclehs.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Adamo Carlo carlo.adamo@chimieparistech.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Organic photovoltaics (OPV) is attracting increasing interest as an alternative to inorganic solar cells due to possible applications in low-cost, low environmental impact, light-weight and large-area flexible devices. An organic solar cell (OSC) basically consists of the heterojunction created by putting into contact an electron donor material (D) with an electron-acceptor. The basic functioning of an OSC consists in four steps: the absorption of an incident photon by the active material (D in general) generates a bound electron-hole pair (exciton) which diffuses in the D phase and dissociates at the D/A interface. The resulting electrons and holes migrate in the D and A layers to be finally collected at the electrodes. The performance of an OSC depends on the efficiency of these four steps that is affected, in turn, by the properties of the materials employed in its fabrication. Its optimal performance requires, therefore, the improvement of the characteristics of each constituent. In this project we focus on the optimization of acceptor and donor materials through first-principles (DFT) approaches and semi-classical charge transport models, using a protocol that we have recently developed. The aim is to to shed light on the structure-properties relationships that rule the

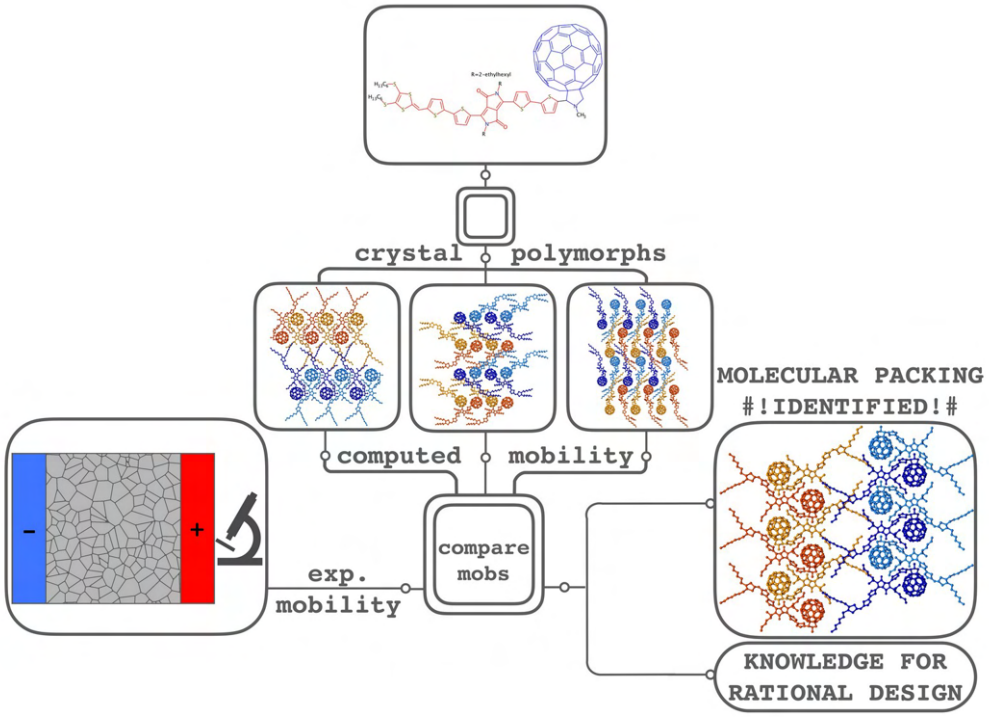
charge and exciton transport in a series of commonly used acceptors and donors, in both crystalline and amorphous phases. A particular attention will be developed to the modeling of the interface of the two components . These relationships will be then used to design new molecular systems with improved performances.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. D. Alberga, G.F. Mangiatordi, F. Labat, I. Ciofini, O. Nicolotti, G. Lattanzi, C. Adamo Theoretical Investigation of Hole Transporter Materials for Energy Devices J. Phys. Chem. C 119 (2015) 23890.
2. D. Alberga, I. Ciofini, G.F. Mangiatordi, A. Pedone, G. Lattanzi, J. Roncali, C. Adamo, Effects of Substituents on Transport Properties of Molecular Materials for Organic Solar Cells: A Theoretical Investigation Chem. Mat 29 (2017) 673.
3. M. Turelli, D. Alberga, G. Lattanzi, I. Ciofini, C.Adamo, Theoretical insights on acceptor–donor dyads for organic photovoltaics Phys; Chem. Chem. Phys. 22 (2020) 27413.
4. M. Turelli, G. Lattanzi, I. Ciofini, C. Adamo On the Interplay between Molecular Packing and Optical Response in Thin Films for Organic Photovoltaics J. Phys. Chem. C 125 (2021) 16304.
5.

Illustrations :


crystal polymorphs
computed mobility
MOLECULAR PACKING
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compare mobs
exp. mobility
KNOWLEDGE FOR RATIONAL DESIGN

ParisTech

TITLE: IN-SILICO DESIGN AND OPTIMIZATION OF MOLECULAR SYSTEMS FOR AGGREGATION-INDUCED EMISSION (AIE)

Topic number : ***2022_049***

Field : Chemistry, Physical chemistry and Chemical Engineering, ,

Subfield: Theoretical chemistry, computational Chemistry

ParisTech School: Chimie ParisTech - PSL
Research team: Theoretical Chemistry and Modeling Group
http://www.quanthic.fr
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:http://www.quanthic.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Ciofini Ilaria ilaria.ciofini@chimieparistech.psl.eu
Advisor 2: Adamo Carlo carlo.adamo@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Aggregation Induced Emission (AIE) is a physical phenomenon concerning a class of molecular materials that exhibit weak or no fluorescence in dilute solution while showing strong fluorescence upon aggregation. The AIE effect opens many opportunities for the development of new luminogen materials with a large variety of potential domain of applications. Nonetheless, the general mechanisms underpinning AIE have not yet been fully elucidated although some general rules have been identified to explain this effect. Generally an increase in the molecular rigidity of the emitting species in going from the solution to the solid (crystalline) phase has been considered as responsible of this phenomenon. However, a detailed analysis of the effect of the molecular environment, which could play a not-negligible role on AIE effect, is still missing.
This project of thesis propose to adapt and apply a modern computational approach that we have recently developed to shed light on the structure-properties relationships that rule the AIE effects. The computational approach is based on a smart combination of quantum (DFT) and classical (MD) simulations to describe the molecular systems both in solution and when aggregated. The relationships identified through these accurate modeling, will be then used to design new systems with improved AIE

performances, in collaboration with experimentalists at the University of Pisa (Italy) involved in the synthesis and characterization of these new materials.

Required background of the student: Physical Chemistry, chemical physics, theoretical chemistry and modelling

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. C. Micheletti, Q. Wang, F. Ventura, M. Turelli, I. Ciofini, C. Adamo, A. Pucci Red-emitting tetraphenyethylene derivative with aggregation-induced enhanced emission for luminescent solar concentrators: a combined experimental and DFT study Aggregates 2022, doi: 10.1002/agt2.188
2. F. Muniz-Miranda, P. Minei, L. Contiero, F. Labat, I. Ciofini, C. Adamo, F. Bellina, A. Pucci “Aggregation effects on pigment coatings: Pigment Red 179 as case study » ACS Omega 2019, 4, 23, 20315-20323
3. L. Wilbraham, M. Louis, D. Alberga, A. Brosseau, R. Guillot, F. Ito, F. Labat, R. Métivier, C. Allain, I. Ciofini “Revealing the origins of mechanically-induced fluorescence changes in organic molecular crystals” Adv. Mat 30(2018) 1800817
4. D. Presti, L. Wilbraham, C. Targa, F. Labat, A. Pedone, M.C. Menziani, I. Ciofini, C. Adamo Understanding Aggregation-Induced Emission in Molecular Crystals: Insights from Theory J. Phys. Chem. C 121 (2017) 5747-5752
5. L. Wilbraham, C. Adamo, F. Labat, I. Ciofini Electrostatic Embedding To Model the Impact of Environment on Photophysical Properties of Molecular Crystals: A Self-Consistent Charge Adjustment Procedure J. Chem. Theory Comp. 12 (2016) 3316-3324

Illustrations :

ParisTech

TITLE: CONSTRUCTION OF CHIRAL DIPHOSPHINES THROUGH RH(III)-CATALYZED ATROPOSELECTIVE C–H BOND FUNCTIONALIZATION AND USE THEREOF IN ASYMMETRIC CATALYSIS

Topic number : ***2022_050***

Field : Chemistry, Physical chemistry and Chemical Engineering, Chemistry, Physical chemistry and Chemical Engineering,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Catalysis, Synthesis of Biomolecules and Sustainable Development Team (CSB2D)
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:https://iclehs.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Soulé Jean-François jean-francois.soule@chimieparistech.psl.eu
Advisor 2: Phansavath Phannarath phannarath.phansavath@chimieparistech.psl.eu
Advisor 3: Vidal Virginie virginie.vidal@chimieparistech.psl.eu
Advisor 4:

Short description of possible research topics for a PhD: Transition-metal catalyzed asymmetric synthesis is one of the most efficient methods to produce optically active compounds. Among various types of chiral ligands, diphosphines play an outstanding role in asymmetric catalysis owing to their tunable properties to switch or improve the regio- and/or enantio-selectivity. Despite a significant number of chiral phosphines commercially available, the preparation of backbone chirality diphosphines sometimes remains problematic owing to a multi-step synthesis using expensive chiral pools. This project wants to speed up the preparation of chiral diphosphines with upgraded properties using, for the first time, asymmetric catalysis based on atroposelective C–H bond functionalizations. The key features to succeed in this approach are 1) avoiding the formation of stable 18-electron complex I and 2) controlling the direction of "rollover-cyclometalation" (intermediate IIA or IIB) to induce high enantioselectivity. Design specifically for this task, the NHC-analogs of the Rh(III)-catalysts developed in the group shall prevent the

coordination of the second phosphorus and control the axial chirality during the rollover-cyclometalation. Besides, all prepared novel chiral diphosphines will be later used for the asymmetric hydrogenation of reluctant substrates.

Required background of the student: The applicant must have good English language. She/he should have a Master's degree in molecular chemistry with solid skills in organic synthesis and organometallic complex preparations (theoretical and practical), including working under an inert atmosphere and mastering the usual characterization techniques. Experience in asymmetric catalysis will be appreciated but not mandatory.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Zhang, Z.; Roisnel, T.; Dixneuf, P. H.; Soulé, J.-F. Angew. Chem. Int. Ed. 2019, 58, 14110

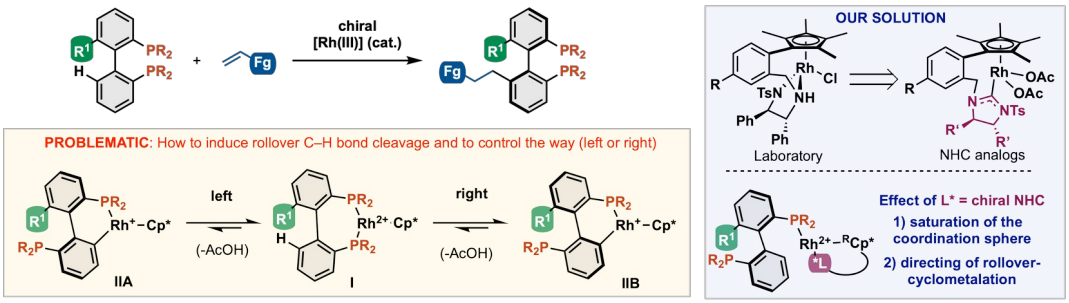
2. Rzayev, J.; Zhang, Z.; Durand, N.; Soulé, J.-F. Org. Lett. 2022, 24, 6755

3. Zheng, L.-S.; Llopis, Q.; Echeverria, P.-G.; Férard, C.; Guillamot, G.; Phansavath, P.; Ratovelomanana-Vidal, V.; J. Org. Chem. 2017, 82, 5615.

4. He, B.; Phansavath, P.; Ratovelomanana-Vidal, V. Org. Lett. 2019, 21, 3276

5. Genêt, J.-P.; Phansavath, P.; Ratovelomanana-Vidal, V. Isr. J. Chem. 2021, 409

Illustrations :



ParisTech

ESPCI PARIS PSL

TITLE: ELECTRONIC STRUCTURE OF THE INTERCALATED GRAPHENE-GE INTERFACES

Topic number : ***2022_051***

Field : Physics, Optics, Material science, Mechanics and Fluids,

Subfield: Surface Science,

ParisTech School: ESPCI Paris - PSL
Research team: Quantulm Specs https://qs.lpem.espci.fr/home
Research lab: LPEM - Laboratoire Physique et d'études des matériaux
Lab location: Paris
Lab website:https://www.lpem.espci.fr/spip.php?rubrique45

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Roditchev Dimitri dimitri.roditchev@espci.fr
Advisor 2: Dedkov Yuriy dedkov@shu.edu.cn
Advisor 3: Vlaic Sergio sergio.vlaic@espci.fr
Advisor 4:

Short description of possible research topics for a PhD: The recent progress in the graphene synthesis on different substrates and the desire to implement graphene in the modern semiconductor technology led to the discovery of graphene synthesis on the catalytically active semiconducting Ge substrates of different orientations. These studies demonstrate that Ge(110) and Ge(111) planes are more suitable for graphene growth, whereas in the case of Ge(001), a significant surface faceting under the graphene layer was found, limiting further technological processing of the latter interface. The recent progress in this area is mainly focused on the growth mechanism of graphene on Ge surfaces, and the studies of the electronic structure of the gr-Ge interface or its modification are very rare.
The present research project focuses on the studies of structure and electronic properties of the graphene-Ge interfaces modified by the intercalation of Mn and Fe. These studies will be performed using state-of-the-art STM and ARPES techniques. The cooperation with partners partners who will perform large-scale DFT calculations is also planned. This work is based on the recent elegant idea to prepare a new graphene/ferromagnet interface, namely, graphene-Mn_5Ge_3, which combines several well-established steps used in graphene-related studies. It is shown that in this strongly interacting system the graphene π states

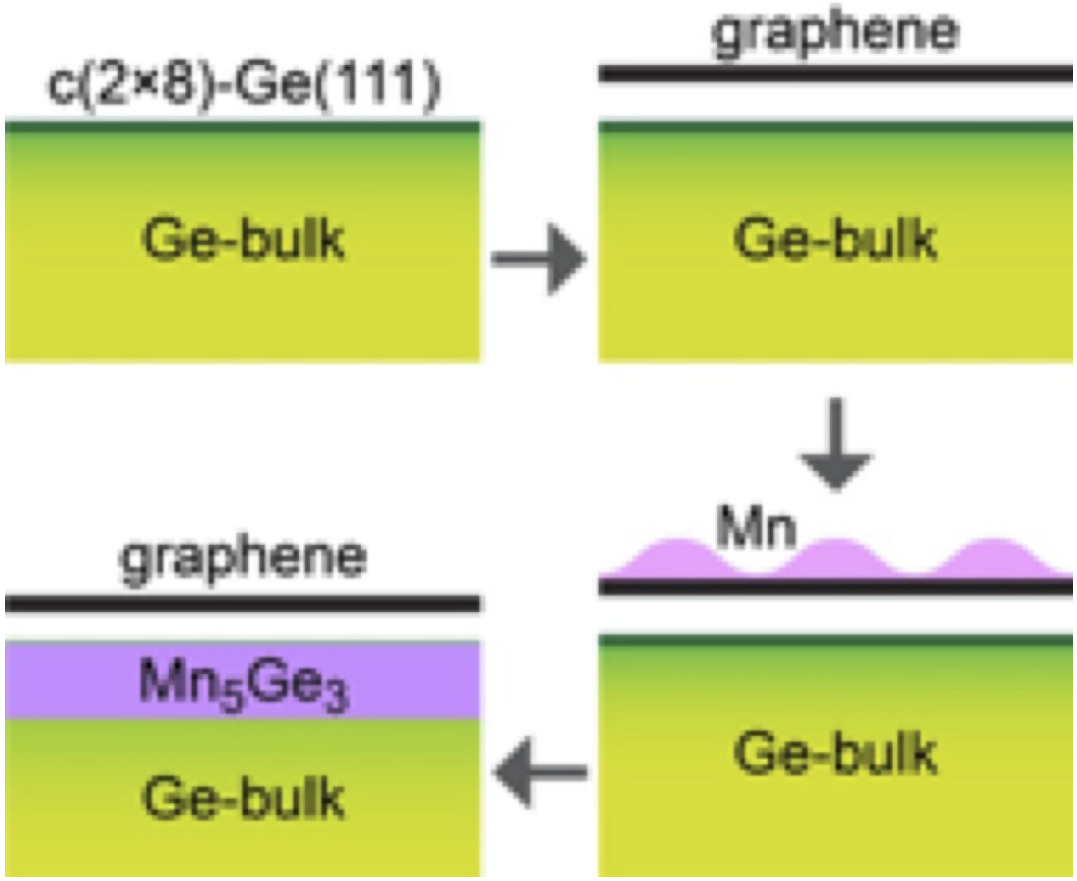
undergo strong exchange split, leaving only spin-up electrons in the vicinity of the Fermi level, which preserve the Dirac-electron-like character for the carriers with a linear energy band dispersion. At the same time, for the spin-down electrons, a series of localized interface states is formed that strongly reduces the carriers' mobility for this spin channel. Such difference for the electron mobilities can lead to the effective spin-filtering effect in such a single-layer graphene-based junction. This project is joint collaboration between the Shanghai University and the ESPCI Paris. The PhD candidate will spend half of the PhD in China and half in France.

Required background of the student: The successful candidate should possess a good background in solid state physics and quantum mechanics. He/She should be at ease in the experimental work, be able to work in team and driven by natural curiosity for science. Experience in experimental research in physics will be a plus.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. K. Wang et al.,. Carbon. 183, 251 (2021).
2. T. Vincent et al., J. Phys. Chem. Lett.. 11, 1594 (2020).
3. Tesch J. et al., Nanoscale 10, 6088 (2018).
4. Y. Dedkov et al., Nanoscale 12, 11416 (2020).
5. E. Voloshina et al., J. Phys. Chem. Lett. 10, 3212 (2019).

Illustrations :


c(2×8)-Ge(111)
Ge-bulk
graphene
Ge-bulk
Mn
graphene
Mn_5Ge_3
Ge-bulk
Ge-bulk

Research Topic for the ParisTech/CSC PhD Program

Field: Physics, Materials Science
Subfield: Physics, Electronic properties of matter, Surface Science
Title: *Electronic structure of the intercalated graphene-Ge interfaces*
ParisTechSchool: ESPCI Paris, PSL Research University

Advisor name: Dimitri Roditchev, ESPCI Paris, PSL Research University
Advisor e-mail: dimitri.roditchev@espci.fr
Co-advisor name: Yuriy Dedkov, Shanghai University
Co-advisor e-mail: dedkov@shu.edu.cn
Co-advisor name: Sergio Vlaic, ESPCI Paris, PSL Research University
Co-advisor e-mail: sergio.vlaic@espci.fr

The recent progress in the graphene synthesis on different substrates and the desire to implement graphene in the modern semiconductor technology led to the discovery of graphene synthesis on the catalytically active semiconducting Ge substrates of different orientations. These studies demonstrate that Ge(110) and Ge(111) planes are more suitable for graphene growth, whereas in the case of Ge(001), a significant surface faceting under the graphene layer was found, limiting further technological processing of the latter interface. The recent progress in this area is mainly focused on the growth mechanism of graphene on Ge surfaces, and the studies of the electronic structure of the gr-Ge interface or its modification are very rare.

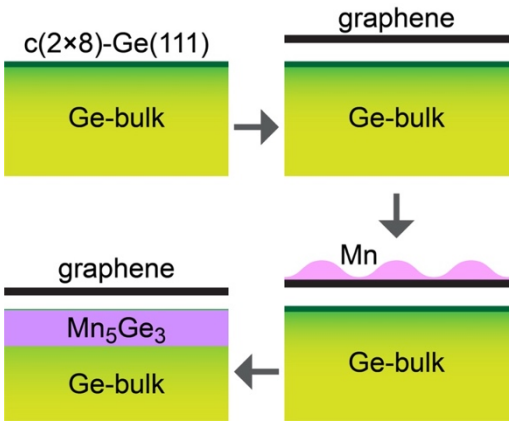


Figura 1 Two-steps preparation procedure for the gr-Mn_5Ge_3(0001) system: (i) graphene on Ge(111) is grown via CVD or MBE; (ii) atomically sharp gr-Mn_5Ge_3(0001) interface is formed via intercalation of the pre-deposited thin layer of Mn on gr-Ge(111).

The present research project focuses on the studies of structure and electronic properties of the graphene-Ge interfaces modified by the intercalation of Mn and Fe. These studies will be performed using state-of-the-art STM and ARPES techniques. The cooperation with partners partners who will perform large-scale DFT calculations is also planned. This work is based on the recent elegant idea to prepare a new graphene/ferromagnet interface, namely, graphene-Mn_5Ge_3, which combines several well-established steps used in graphene-related studies. It is shown that in this strongly interacting system the graphene π states undergo strong exchange split, leaving only spin-up electrons in the vicinity of the Fermi level, which preserve the Dirac-electron-like character for the carriers with a linear energy band dispersion. At the same time, for the spin-down electrons, a series of localized interface states is formed that strongly reduces the carriers' mobility for this spin channel. Such difference for the electron mobilities can lead to the effective spin-filtering effect in such a single-layer graphene-based junction. This project is joint collaboration between the Shanghai University and the ESPCI Paris. The PhD candidate will spend half of the PhD in China and half in France.

Candidate profile: The successful candidate should possess a good background in solid state physics and quantum mechanics. He/She should be at ease in the experimental work, be able to work in team and driven by natural curiosity for science. Experience in experimental research in physics will be a plus.

A list of 5 (max.) representative publications of the group (Related to the research topic)

1) K. Wang *et al*.,. **Carbon. 183**, 251 (2021).
2) T. Vincent *et al*., **J. Phys. Chem. Lett.. 11**, 1594 (2020).
3) Tesch J. *et al*., **Nanoscale 10**, 6088 (2018).
4) Y. Dedkov *et al*., **Nanoscale 12**, 11416 (2020).
5) E. Voloshina *et al*., **J. Phys. Chem. Lett. 10**, 3212 (2019) .

ParisTech

TITLE: MECHANOCHEMISTRY-ASSISTED CONTINUOUS SYNTHESIS OF ORGANOMETALLIC COMPLEXES OF MEDICINAL RELEVANCE

Topic number : ***2022_052***

Field : Chemistry, Physical chemistry and Chemical Engineering, Life and Health Science and Technology,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Catalysis, Synthesis of Biomolecules and Sustainable Development Team (CSB2D) and Inorganic Chemical Biology Team (ICB) https://www.lenresearch.com
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:HTTPS://WWW.CHIMIEPARISTECH.PSL.EU/RECHERCHE/LES-LABORATOIRES/I-CLEHS/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: LEN CHRISTOPHE christophe.len@chimieparistech.psl.eu
Advisor 2: CARIOU KEVIN kevin.cariou@chimieparistech.psl.eu
Advisor 3: GASSER GILLES gilles.gasser@chimieparistech.psl.eu
Advisor 4:

Short description of possible research topics for a PhD: Over the recent years, organometallic compounds have shown enormous potential in medicinal chemistry and chemical biology.1,2 Ferroquine, an antimalarial drug candidate, is a ferrocenyl analogue of the antimalarial drug Chloroquine which is currently undergoing phase IIb clinical trial.3 The addition of a metal complex has allowed metal-specific modes of action to be uncovered, which has enabled resistance to be overcome and/or the bioactivity of the organic drug to be enhanced.
Among the recent advances in green chemistry and sustainable development, alternative technologies such as continuous flow and ball-milling have been reported.4,5 Continuous flow chemistry and alternative technology-assisted continuous flow offers significant advantages including improved thermal management, mixing control, application to a wider range of reaction conditions, scalability, energy efficiency, waste reduction, safety, use heterogeneous catalysis and multistep synthesis.

In this project, we envisage to produce novel ferrocenyl derivatives as drug candidates in either continuous flow or alternative technologies-assisted continuous flow. Iron complexes have been found to be extremely promising anticancer and antiparasitic drug candidates. In order to improve the sustainability of the API production, the main tools and levers developed in this subject will be (i) the substitution of Ru(II) as noble metal by Fe(II) as non-noble metal; (ii) the use of continuous flow process and mechanochemical approach; (iii) the use of green solvent.

Required background of the student: Organic chemistry, bio-inorganic chemistry, catalysis, continuous flow

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Patra, M.; Gasser , G. The Medicinal Chemistry of Ferrocene and its Derivatives. Nature Rev. Chem. 2017, 1, 0066.

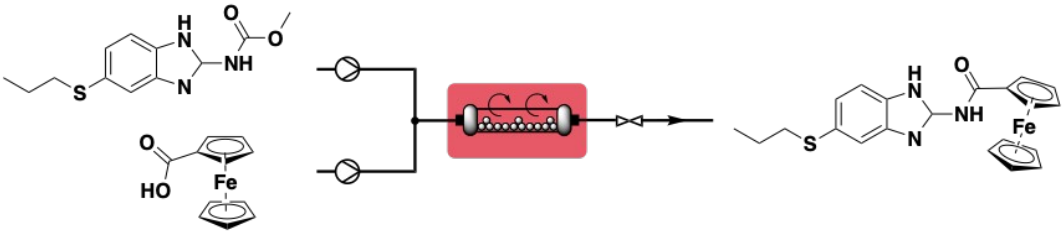
2. Jaouen, G.; Vessières, A.; Top, S. Ferrocifen type anti cancer drugs. Chem. Soc. Rev. 2015, 44 (24), 8802-8817.

3. Dubar, F.; Slomianny, C.; Khalife, J.; Dive, D.; Kalamou, H.; Guérardel, Y.; Grellier, P.; Biot, C. The ferroquine antimalarial conundrum : redox activation and reinvasion inhibition. Angew. Chem. Int. Ed. 2013, 52, 7690–7693.

4. Su, Y.; Zhao, D.; Wang, Y.; Lu, H.; Varma, R.S.; Len, C. Innovative protocols in the catalytic oxidation of 5-hydroxymethylfurfural. ChemSusChem 2021, 14, 266-280.

5. Trombettoni, V.; Franco, A.; Sathicq, G.A.; Len, C.; Romanelli, G.P.; Vaccaro, L.; Luque, R. Efficient liquid -assisted grinding selective aqueous oxidation of sulfides using supported heteropolyacid catalysts, ChemCatChem 2019, 11, 2537-2545.

Illustrations :



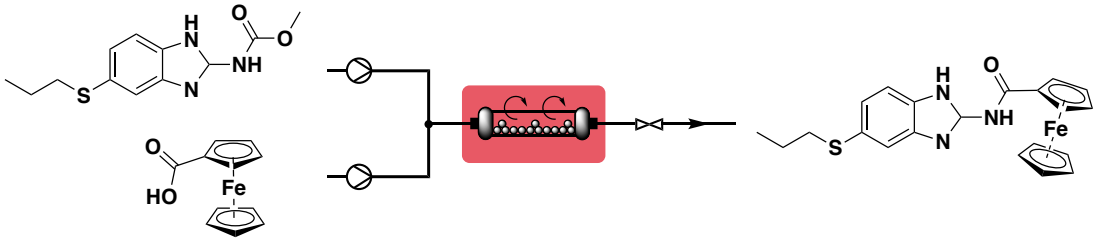
Mechanochemistry-Assisted Continuous Synthesis of Organometallic Complexes of Medicinal Relevance

Christophe Len, Kevin Cariou & Gilles Gasser

Over the recent years, organometallic compounds have shown enormous potential in medicinal chemistry and chemical biology.[1,2] Ferroquine, an antimalarial drug candidate, is a ferrocenyl analogue of the antimalarial drug Chloroquine which is currently undergoing phase IIb clinical trial.[3] The addition of a metal complex has allowed *metal-specific modes of action* to be uncovered, which has enabled resistance to be overcome and/or the bioactivity of the organic drug to be enhanced.

Among the recent advances in green chemistry and sustainable development, alternative technologies such as continuous flow and ball-milling have been reported.[4,5] Continuous flow chemistry and alternative technology-assisted continuous flow offers significant advantages including improved thermal management, mixing control, application to a wider range of reaction conditions, scalability, energy efficiency, waste reduction, safety, use heterogeneous catalysis and multistep synthesis.

In this project, we envisage to produce novel ferrocenyl derivatives as drug candidates in either continuous flow or alternative technologies-assisted continuous flow. Iron complexes have been found to be extremely promising anticancer and antiparasitic drug candidates.[6] In order to improve the sustainability of the API production, the main tools and levers developed in this subject will be (i) the substitution of Ru(II) as noble metal by Fe(II) as non-noble metal; (ii) the use of continuous flow process and mechanochemical approach; (iii) the use of green solvent (Scheme 1).



Scheme 1. Example of the synthetic pathway for the preparation of a ferrocenyl albendazole derivative using mechanochemistry-assisted continuous flow.

References

(1) Patra, M.; Gasser , G. The Medicinal Chemistry of Ferrocene and its Derivatives. *Nature Rev. Chem.* **2017,** *1*, 0066, and references therein.

(2) Jaouen, G.; Vessières, A.; Top, S. Ferrocifen type anti cancer drugs. *Chem. Soc. Rev.* **2015,** *44* (24), 8802-8817, and references therein.

(3) Dubar, F.; Slomianny, C.; Khalife, J.; Dive, D.; Kalamou, H.; Guérardel, Y.; Grellier, P.; Biot, C. The ferroquine antimalarial conundrum : redox activation and reinvasion inhibition. *Angew. Chem. Int. Ed.* **2013,** *52*, 7690–7693.

(4) Su, Y.; Zhao, D.; Wang, Y.; Lu, H.; Varma, R.S.; Len, C. Innovative protocols in the catalytic oxidation of 5-hydroxymethylfurfural. *ChemSusChem* **2021**, *14*, 266-280.

(5) Trombettoni, V.; Franco, A.; Sathicq, G.A.; Len, C.; Romanelli, G.P.; Vaccaro, L.; Luque, R. Efficient liquid - assisted grinding selective aqueous oxidation of sulfides using supported heteropolyacid catalysts, *ChemCatChem* **2019**, *11*, 2537-2545.

(6) Lin, Y.; Betts, H.; Keller, S.; Cariou, K.; Gasser, G. Recent developments of metal-based compounds against fungal pathogens. *Chem. Soc. Rev.* **2021,** *50* (18), 10346-10402.

To respond to this offer:

Full CV, covering letter of recommendation to be send by e-mail to: christophe.len@chimieparistech.psl.eu and gilles.gasser@chimieparistech.psl.eu

TITLE: PGD SOLUTION OF BEAM, PLATE AND SHELL STRUCTURES MADE OF FUNCTIONALLY GRADED MATERIALS IN THERMAL ENVIRONMENT

Topic number : ***2022_054***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: DIPPE https://lampa.ensam.eu/accueil-lampa-100748.kjsp
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:https://lampa.ensam.eu/accueil-lampa-100748.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: AMMAR Amine Amine.AMMAR@ensam.eu
Advisor 2: Kazemzadeh-Parsi Mohammadjavad Mohammadjavad.KAZEMZADEHPARSI@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Functionally Graded Materials (FGM) are new class of composite materials that their mechanical properties evolve continuously in space. In traditional composite materials, the mechanical properties change sharply at the interface of different phases and this leads to high interfacial stresses and in many times the origin of failure. Whereas, the gradual variation of material properties in FGM materials prevents from such behaviors. This feature makes the FGM as the ideal choice in severe thermal environments and make it possible to have a part with pure metallic phase at one point to satisfy strength and pure ceramic phase at other point to resist again high temperature. Optimal design of FGM materials consists of accurate determination of spatial distribution of concentration of constituents. Recent technologies use additive manufacturing to produce FGM materials and consequently the FGM parts with multi directional material variations are realistic today.

The design of FGM materials consists of accurate determination of spatial volume fraction distribution of constituents. To do this, a material

distribution model with one or more controlling parameters is used. A parametric study is then needed to investigate the effect of material distribution parameters on the mechanical performance of the whole component. The Proper Generalized Decomposition (PGD) technique is a recent method that circumvents the curse of dimensionality and allows among other things to solve parametric problems while avoiding computational explosion. The main objective of the present project is obtaining parametric PGD solution of structural components such as beams, plates and shells under thermal and mechanical loadings.

Required background of the student: FEM, Numerical Methods, continuum mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M.J Kazemzadeh-Parsi, F. Chinesta, A. Ammar, Proper generalized decomposition for parametric study and material distribution design of multi-directional functionally graded plates based on 3D elasticity solution, Materials, 2021, 14, 6660. (https://doi.org/10.3390/ma14216660)
2. M.J. Kazemzadeh-Parsi, A. Ammar, F. Chinesta, Parametric analysis of thick FGM plates based on 3D thermos-elasticity theory: a PGD approach, submitted to Computers & Mathematics with Applications, 2022.
3. M. Khakpour, Y. Bazargan-Lari, P. Zahedinejad, M.J. Kazemzadeh-Parsi, Vibrations Evaluation of Functionally Graded Porous Beams in Thermal Surroundings by Generalized Differential Quadrature Method, Shock and Vibration, 2022, Article ID 8516971. (https://doi.org/10.1155/2022/8516971)
4. M. Forghani, Y. Bazargan-Lari, P. Zahedinejad, M.J. Kazemzadeh-Parsi, Nonlinear frequency behavior of cracked functionally graded porous beams resting on elastic foundation using Reddy shear deformation theory, Journal of Vibration and Control, April 21, 2022. (https://doi.org/10.1177/10775463221080213)
5.

Illustrations :

ParisTech

TITLE: CHEMICAL BONDING OF GRAPHENE ON TIO2 FOR BOOSTED INTERFACIAL CHARGE TRANSFER IN OPTOELECTRONIC DEVICES

Topic number : ***2022_055***

Field : Chemistry, Physical chemistry and Chemical Engineering, ,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: MPOE
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.chimieparistech.psl.eu/recherche/les-laboratoires/ircp/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Pauporté Thierry thierry.pauporte@chimieparistech.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Titanium dioxide, as a stable large bandgap oxide semiconductor is employed in a large extend in optoelectronics. Its combination with graphene has been developed to improve electronic conduction, charge separation and visible light absorbance. A high-quality interface between graphene and TiO2, free of recombination centers, such as adsorbates or contamination, and with a well-established chemical contact between both materials is critical for charge separation. Importantly, it is key to achieve chemical bonding between graphene and TiO2. The present thesis will aim at developing reproducible and efficient techniques to bind the two components and prepare mesoporous composite layers. These layers will be fully characterized. The charge transfer will be studied and optimized. Finally, the layers will be applied in photodetector and in perovskite solar cells devices.

Required background of the student: Materials sciences, semiconductors, inorganic chemistry, solar cells

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. R. Zouzelka, Y. Kusumawati, M. Remzova, J. Rathousky, Th Pauporté, Photocatalytic activity of porous multiwalled carbon nanotube-TiO2 composite layers for pollutant degradation. J. Hazard. Mater., 317 (2016) 52–59.
2. T. Zhu, J. Su, J. Alvarez, G. Lefèvre, F. Labat, I. Ciofini, Th. Pauporté, Response Enhancement of Self-Powered Visible-Blind UV Photodetectors by Nanostructured Heterointerface Engineering. Adv. Funct. Mater., 29 (2019) 1903981.
3. D. Zheng, T. Zhu, Y. Yan, Th. Pauporté, Controlling the formation process of methylammonium-free halide perovskite films for a homogeneous incorporation of alkali metal cations beneficial to solar cell performances. Adv. Energy Mater., 12 (2022) 2103618.
4. Y. Kusumawati, M. A. Martoprawiro, Th. Pauporté, Effects of Graphene in Graphene/TiO2 Composite Films Applied to Solar Cell Photoelectrode. J. Phys. Chem. C, 118 (19) (2014) 9974–9981.
5. H. Zhang, A. V. Babichev, G. Jacopin, P. Lavenus, F. H. Julien, A. Yu. Egorov, Th. Pauporté, M. Tchernycheva, Characterization and modeling of a ZnO nanowire ultraviolet photodetector with a graphene transparent contact. J. Appl. Phys., 114 (2013) 234505.

Illustrations :

ParisTech

Arts et Métiers

TITLE: INTELLIGENT HAPTICS FOR THE PERCEPTION OF FLUID PROPERTIES

Topic number : ***2022_056***

Field : Information and Communication Science and Technology, Material science, Mechanics and Fluids,

Subfield: Medical application for Diagnostics and Prognostics

ParisTech School: Arts et Métiers
Research team:
Research lab: LIFSE - Laboratoire Ingénierie des Fluides Systèmes Energétiques
Lab location: Paris
Lab website:HTTPS://LIFSE.ARTSETMETIERS.FR/

Contact point for this topic: Arts et Métiers

Advisor 1: GARBAYA Samir samir.garbaya@ensam.eu
Advisor 2: KHELLADI Sofiane Sofiane.KHELLADI@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Multi-modal interaction provides the user with multiple sensory inputs that improve human perception in the cyber-physical systems . Haptic sensation is crucial for the perception of the properties of physical objects including fluids in specific interactive conditions . However, despite the great interest of research in modelling fluids dynamics in virtual environment still natural haptic feedback allowing the perception of fluid properties with high fidelity is not available . This is due to the methodology used for modeling the hydrodynamics of virtual fluids and/or the constraints inherent to the technology of haptic interface .
This PhD will focus on the development of graphics modeling methodologies of virtual fluids and the design novel 3D haptic interaction techniques. The research involves the development of sensory integration (such as visuo-haptics) and the mechanisms of sensory substitution for the perception of fluids properties. This work will integrate machine learning and augmented reality in the Human-Computer Interaction loop to improve the fidelity of the exploration of virtual environments.
The successful candidate will have to identify the limitations of current interaction techniques for haptic perception of virtual fluids and evaluate existing tools (software and interfaces). He/she will develop new methods

of hydrodynamics modeling and interaction techniques based on Extended-Realty for the augmentation of user perception of fluids properties.
The PhD results will be validated and used for applications such as medical palpation and the perception of fluid properties in conditions of visual occlusion.

Required background of the student: Applicants must have completed a Master of Science (Engineering) in a discipline related to computer science or mechanical engineering.
Prospective applicants must have proven track record in the following skills:
- Computer Graphics, 3D Visualization,
- Computational Fluid Dynamics
- Good programming skills in C++, C#
- Machine learning
- Good writing and oral communication skills in English
- Motivation for Human Perception, or Cognitive Sciences

Basic knowledge of Virtual and Augmented Reality will be appreciated.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Bertelson, Paul, and Béatrice De Gelder, 'The Psychology of Multimodal Perception', in Charles Spence, and Jon Driver (eds), Crossmodal Space and Crossmodal Attention (Oxford, 2004; online edn, Oxford Academic, 22 Mar. 2012), https://doi.org/10.1093/acprof:oso/9780198524861.003.0007, accessed 10 Oct. 2022.

2. Reed, Catherine & Ziat, Mounia. (2018). Haptic Perception: From the Skin to the Brain. 10.1016/B978-0-12-809324-5.03182-5.

3. Richardson BA, Kuchenbecker KJ. Learning to Predict Perceptual Distributions of Haptic Adjectives. Front Neurorobot. 2020 Feb 6; 13:116. doi: 10.3389/fnbot.2019.00116. PMID: 32116631; PMCID: PMC7016190.

4. Lundin, Karljohan & Sillén, Mattias & Cooper, Matthew & Ynnerman, Anders & Visualization, Norrköping & Studio, Interaction & Sweden, (2005). Haptic visualization of computational fluid dynamics data using reactive forces. Proceedings of SPIE - The International Society for Optical Engineering. 5669. 10.1117/12.587029.

5. Liu, S., Ma, C. & Feng, G. Haptic rendering for the coupling between fluid and deformable object. Virtual Reality 23, 33–44 (2019). https://doi.org/10.1007/s10055-018-0351-6

Illustrations :

TITLE: MULTI-PHYSICAL/MULTI-SCALE MODELLING AND EXPERIMENTAL ANALYSIS OF SURFACE INTEGRITY IN MACHINING OF INCONEL 718 ALLOY USING ADVANCED CUTTING TOOLS MATERIALS

Topic number : ***2022_057***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: UGV
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:https://labomap.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Birembaux Hélène helene.birembaux@ensam.eu
Advisor 2: OUTEIRO José jose.outeiro@ensam.eu
Advisor 3: ROSSI Frédéric frederic.rossi@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The machining industry is constantly looking for new solutions to increase productivity and the quality of finished products and in the same time to reduce the ecological and economic impacts of the process (durability, recycling, etc..).
Today, cemented carbides are the most used cutting tool material in industry. In 2017, the worldwide production of cemented carbide exceeded 90,000 tons, with 65% consumed by the machining industry. The objective of this project is to study and optimize the cutting process of Inconel 718 alloy using an advanced tool material (e.g. PCBN), this last is more advantageous in terms of wear, durability comparing to cemented carbide tools used commonly in manufacturing aerospace components.

Required background of the student: 1. A master's degree in mechanical engineering. The candidate must have a good knowledge in machining techniques and a strong taste for rigorous implantation of highly instrumented experimental procedures. He (or she) must have good programming skills in numerical simulation.

2. Ability to work independently, to plan and carry out tasks.
3. Good communication skills in English, written and spoken.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Liu, H., Ayed, Y., Birembaux, H., Rossi, F., & Poulachon. G. (2022). Impacts of flank wear and cooling strategies on evolutions of built-up edges, diffusion wear and cutting forces in Ti6Al4V machining. Tribology international, 171, 107537. DOI: 10.1016/j.triboint.2022.107537.
2. Liu, H., Birembaux, H., Ayed, Y., Rossi, F., & Poulachon, G. (2021). A hybrid modelling approach for characterizing hole shrinkage mechanisms in drilling Ti6Al4V under dry and cryogenic conditions. The International Journal of Advanced Manufacturing Technology, 1-20. DOI: 10.1007/s00170-021-08229-2.
3. X. Xu, Jun Zhang, J.C. Outeiro, B. Xu, W. Zhao. (2020). Multiscale simulation of grain refinement induced by dynamic recrystallization of Ti6Al4V alloy during high speed machining, Journal of Materials Processing Technology, Vol. 286, pp. 116834, ISSN 0924-0136; I.F. 3.647.
4. R M'saoubi, T. Larsson, J.C. Outeiro, Y. Guo, S. Suslov, C. Saldana, S. Chandrasekar. (2012). "Surface integrity analysis of machined Inconel 718 over multiple length scales", CIRP Annals - Manufacturing Technology, Vol. 61/1, pp. 99-102.
5. J. C. Outeiro, J. C. Pina, R. M'saoubi, F. Pusavec, I. S. Jawahir. (2008). "Analysis of Residual Stresses Induced by Dry Turning of Difficult-to-machine Materials", CIRP Annals - Manufacturing Technology, Vol. 57, pp. 77–80.

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Materials Science, Mechanics, Fluids
Subfield: Mechanical Engineering

Title: Multi-physical/multi-scale modelling and experimental analysis of surface integrity in machining of Inconel 718 alloy using advanced cutting tools materials
ParisTech School: Arts et Métiers Sciences et Technologies
Advisor(s) Name: José OUTEIRO, Frédéric ROSSI, Hélène BIREMBAUX
Advisor(s)Email: jose.outeiro@ensam.eu, frederic.rossi@ensam.eu
helene.birembaux@ensam.eu
Research group/Lab: Arts et Métiers, ParisTech, LaBoMaP, UBFC
Lab location: F-71250 Cluny, France
(Lab/Advisor website): http://labomap.ensam.eu/
Short description of possible research topics for a PhD:

The machining industry is constantly looking for new solutions to increase productivity and the quality of finished products and in the same time to reduce the ecological and economic impacts of the process (durability, recycling, etc..).
Today, cemented carbides are the most used cutting tool material in industry. In 2017, the worldwide production of cemented carbide exceeded 90,000 tons, with 65% consumed by the machining industry. The objective of this project is to study and optimize the cutting process of Inconel 718 alloy using an advanced tool material (e.g. PCBN), this last is more advantageous in terms of wear, durability comparing to cemented carbide tools used commonly in manufacturing aerospace components.

The study will be realized in two main steps:

- Experimental analysis of the surface integrity in machined of Inconel 718

In this part, machining tests will be performed over Inconel 718 alloy using both cemented carbide and advanced cutting tool materials, different metal working fluids and cutting regime parameters. These tests will be carried out on a CNC lathe machine equipped with experimental set-ups to measure the material strain (by high speed camera) the forces and temperatures during the machining operation. Surface integrity of the surfaces of the samples will be measured.

- Multi-physical simulation of Surface Integrity (SI) in machining of Inconel 718

This step aims to predict the SI (residual stresses, plastic deformation, microhardness, and microstructure…) induced by machining Inconel 718 using both cemented carbide (as industrial reference) and advanced cutting tool materials (e. g. PCBN) under different metal working fluids (mixture oil-water and super critical CO2) and cutting regime parameters. For this purpose, a Finite Element Model using Abaqus software code will be developed. It aims to simulate the material deformation in machining, allowing chip formation and chip serration typical of machining Inconel 718 alloys. The Finite element model will be validated by comparing experimental tests and numerical simulations.

***Required background of the student*:**

1. A master's degree in mechanical engineering. The candidate must have a good knowledge in machining techniques and a strong taste for rigorous implantation of highly instrumented experimental procedures. He (or she) must have good programming skills in numerical simulation.
2. Ability to work independently, to plan and carry out tasks.
3. Good communication skills in English, written and spoken.

A list of 5 (max.) representative publications of the group:

Liu, H., Ayed, Y., Birembaux, H., Rossi, F., & Poulachon. G. (2022). Impacts of flank wear and cooling strategies on evolutions of built-up edges, diffusion wear and cutting forces in Ti6Al4V machining. *Tribology international*, 171, 107537. DOI: 10.1016/j.triboint.2022.107537.

Liu, H., Birembaux, H., Ayed, Y., Rossi, F., & Poulachon, G. (2021). A hybrid modelling approach for characterizing hole shrinkage mechanisms in drilling Ti6Al4V under dry and cryogenic conditions. *The International Journal of Advanced Manufacturing Technology*, 1-20. DOI: 10.1007/s00170-021-08229-2.

X. Xu, Jun Zhang, J.C. Outeiro, B. Xu, W. Zhao, Multiscale simulation of grain refinement induced by dynamic recrystallization of Ti6Al4V alloy during high speed machining, Journal of Materials Processing Technology, Vol. 286, pp. 116834 (16 pages), 2020 (ISSN 0924-0136; I.F. 3.647).

J. C. Outeiro, J. C. Pina, R. M'saoubi, F. Pusavec, I. S. Jawahir, "Analysis of Residual Stresses Induced by Dry Turning of Difficult-to-machine Materials", CIRP Annals - Manufacturing Technology, Vol. 57, pp. 77–80, 2008.

R M'saoubi, T. Larsson, J.C. Outeiro, Y. Guo, S. Suslov, C. Saldana, S. Chandrasekar, "Surface integrity analysis of machined Inconel 718 over multiple length scales", CIRP Annals - Manufacturing Technology, Vol. 61/1, pp. 99-102, 2012.

TITLE: REINFORCEMENT LEARNING-BASED 3D RECONSTRUCTION OF CAD MODELS FROM DEAD MODELS FOR SMART MANUFACTURING APPLICATIONS

Topic number : ***2022_058***

Field : Information and Communication Science and Technology, Design, Industrialization, Mathematics and their applications

Subfield:

ParisTech School: Arts et Métiers
Research team: System engineering and digital mockup
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Aix-en-Provence
Lab website:https://lispen.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: PERNOT Jean-Philippe jean-philippe.pernot@ensam.eu
Advisor 2: POLETTE Arnaud arnaud.polette@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: This PhD program addresses the way dead CAD models (as defined in STEP files) can be reverse engineered to discover the possible building trees from which they may originate, and more precisely the ones adapted for smart manufacturing applications. Such an approach is particularly interesting to define the bill of operations adapted to a given manufacturing process, but also to automatically generate the set of CAD models associated to the manufacturing steps. Indeed, being able to compare the CAD model at a given step to its manufactured and digitized counterpart is of major interest for control purposes and process optimization in the context of the Industry 4.0. The main idea relies in the use of reinforcement learning able to learn how to perform those complex tasks in a very efficient way, and without requiring large databases. Starting from state-of-the-art and known geometric and manufacturing rules to be established with the environment, an autonomous agent will learn the different actions to be applied at the feature level to move towards the next steps, with a known final objective that is the dead CAD model used as input of the algorithm. This singularity will be exploited to define the reward function to be

optimized step after step. The proposed framework will be implemented and validated on academic as well as industrial examples

Required background of the student: Computer science, geometric modeling, computer-aided design.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. V. Samsonov, K. Ben Hicham, T. Meisen, Reinforcement Learning in Manufacturing Control: Baselines, challenges and ways forward, Engineering Applications of Artificial Intelligence, Vol. 112, pp. 104868, 2022.
2. H. Lee, J. Lee, H. Kim, D. Mun, Dataset and method for deep learning-based reconstruction of 3D CAD models containing machining features for mechanical parts, Journal of Computational Design and Engineering, Vol. 9(1), , pp. 114-127, 2022.
3. Peuzin-Jubert M., Polette A., Nozais D., Mari J-L., Pernot J-P., Survey on the View Planning Problem for reverse engineering and automated control applications, Computer-Aided Design, vol. 141, 103094, 2021
4. Hu S., Polette A., Pernot J-P., SMA-Net: Deep learning-based identification and fitting of CAD models from point clouds, Engineering with Computers, 2022. https://doi.org/10.1007/s00366-022-01648-z
5.

Illustrations :

Research Topic for the ParisTech/CSC PhD Program

Fields: Design & Industrialization, Information and Communication Sciences and Technologies, Mathematics and their applications.

ParisTech School : Arts et Métiers Sciences and Technologies – Laboratory LISPEN Campus of Aix-en-Provence

Title : **Reinforcement learning-based 3D reconstruction of CAD models from dead models for smart manufacturing applications**

Advisor(s):
Prof. Dr. Jean-Philippe PERNOT / jean-philippe.pernot@ensam.eu / https://lispen.ensam.eu
Dr. Arnaud POLETTE / arnaud.polette@ensam.eu / https://lispen.ensam.eu

Short description of possible research topics for a PhD :
This PhD program addresses the way dead CAD models (as defined in STEP files) can be reverse engineered to discover the possible building trees from which they may originate, and more precisely the ones adapted for smart manufacturing applications. Such an approach is particularly interesting to define the bill of operations adapted to a given manufacturing process, but also to automatically generate the set of CAD models associated to the manufacturing steps. Indeed, being able to compare the CAD model at a given step to its manufactured and digitized counterpart is of major interest for control purposes and process optimization in the context of the Industry 4.0. The main idea relies in the use of reinforcement learning able to learn how to perform those complex tasks in a very efficient way, and without requiring large databases. Starting from state-of-the-art and known geometric and manufacturing rules to be established with the environment, an autonomous agent will learn the different actions to be applied at the feature level to move towards the next steps, with a known final objective that is the dead CAD model used as input of the algorithm. This singularity will be exploited to define the reward function to be optimized step after step. The proposed framework will be implemented and validated on academic as well as industrial examples.

Required background: Computer science, geometric modeling, computer-aided design.

A list of 5 (max.) representative publications of the group:
Mikchevitch A., Pernot J-P., Methodology for automatic recovering of 3D partitions from unstitched faces of non-manifold CAD models, Engineering with Computers, vol. 31(1), pp. 73-84, 2015.
Lupinetti K., Pernot J-P., Monti M., Giannini F., Content-based CAD assembly model retrieval: Survey and future challenges, Computer-Aided Design, vol. 113, pp. 62-81, 2019.
Surleraux A., Lepert R., Pernot J-P., Kerfriden P., Bigot S., Machine Learning-based reverse modelling approach for rapid tool shape optimization in die-sinking micro Electro Discharge Machining, Journal of Computing and Information Science in Engineering, vol. 20(3), pp. 031002-1 à 11, 2020.
Peuzin-Jubert M., Polette A., Nozais D., Mari J-L., Pernot J-P., Survey on the View Planning Problem for reverse engineering and automated control applications, Computer-Aided Design, vol. 141, 103094, 2021.
Hu S., Polette A., Pernot J-P., SMA-Net: Deep learning-based identification and fitting of CAD models from point clouds, Engineering with Computers, 2022. https://doi.org/10.1007/s00366-022-01648-z

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: TOPOLOGY-PRESERVING NON-RIGID DEFORMATION OF CAD MODELS FROM POINT CLOUDS FOR FIRST-TIME-RIGHT PRODUCTION IN SMART MANUFACTURING

Topic number : ***2022_059***

Field : Information and Communication Science and Technology, Design, Industrialization, Mathematics and their applications

Subfield:

ParisTech School: Arts et Métiers
Research team: System engineering and digital mockup
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Aix-en-Provence
Lab website:https://lispen.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: PERNOT Jean-Philippe jean-philippe.pernot@ensam.eu
Advisor 2: POLETTE Arnaud arnaud.polette@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: This PhD program addresses the way CAD models can be adapted and deformed to capture the manufacturing defaults and thus maintain the coherence between the digital model and its physical and manufactured counterpart. This is particularly useful to optimize tool paths and manufacturing parameters. New deformation operators will be developed to simulate and reproduce various state-of-the-art manufacturing behaviors and deviations, including free-form and non-rigid deformations. Those operators will be applied until the deviation between the CAD model and the acquired point cloud of the manufactured counterpart is minimized. During the deformation process, the topology of the CAD models will be preserved, to be able to maintain the whole coherency and possibly available semantic information. Based on these newly defined capabilities, it will also be possible to deform CAD models a priori, i.e. without any point cloud to serve as a reference and prior to the start of the manufacturing process or before a new manufacturing step, in order to compensate for future deviations and allow for first-time-right production. This will be made possible thanks to the use of a

reinforcement learning strategy, wherein an autonomous agent will learn how to define the deformation sequence to be applied to compensate the coming shape deviations between the theoretical model and its manufactured counterpart. Following this strategy, it will therefore be possible to mix both known rules coming from existing machine fault modeling theories, as well as unknown rules to be learned from experience. The proposed framework will be implemented and validated on academic as well as industrial examples.

Required background of the student: Computer science, geometric modeling, computer-aided design.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Surleraux A., Pernot J-P., Elkaseer A., Bigot S., Iterative surface warping to shape craters in micro-EDM simulation, Engineering with Computers, vol. 32(3), pp. 517-531, 2016
2. Surleraux A., Lepert R., Pernot J-P., Kerfriden P., Bigot S., Machine Learning-based reverse model-ling approach for rapid tool shape optimization in die-sinking micro Electro Discharge Machining, Journal of Computing and Information Science in Engineering, vol. 20(3), pp. 031002-1 à 11, 2020
3. Shah G. A., Polette A., Pernot J-P., Giannini F., Monti M., Simulated annealing-based fitting of CAD models to point clouds of mechanical parts' assemblies, Engineering with Computers, vol. 37(4), pp. 2891-2909, 2021.
4. Peuzin-Jubert M., Polette A., Nozais D., Mari J-L., Pernot J-P., Survey on the View Planning Problem for reverse engineering and automated control applications, Computer-Aided Design, vol. 141, 103094, 2021
5. Hu S., Polette A., Pernot J-P., SMA-Net: Deep learning-based identification and fitting of CAD models from point clouds, Engineering with Computers, 2022. https://doi.org/10.1007/s00366-022-01648-z

Illustrations :

Research Topic for the ParisTech/CSC PhD Program

Fields: Design & Industrialization, Information and Communication Sciences and Technologies, Mathematics and their applications.

ParisTech School : Arts et Métiers Sciences and Technologies – Laboratory LISPEN Campus of Aix-en-Provence

Title : **Topology-preserving non-rigid deformation of CAD models from point clouds for first-time-right production in smart manufacturing**

Advisor(s):
Prof. Dr. Jean-Philippe PERNOT / jean-philippe.pernot@ensam.eu / https://lispen.ensam.eu
Dr. Arnaud POLETTE / arnaud.polette@ensam.eu / https://lispen.ensam.eu

Short description of possible research topics for a PhD :
This PhD program addresses the way CAD models can be adapted and deformed to capture the manufacturing defaults and thus maintain the coherence between the digital model and its physical and manufactured counterpart. This is particularly useful to optimize tool paths and manufacturing parameters. New deformation operators will be developed to simulate and reproduce various state-of-the-art manufacturing behaviors and deviations, including free-form and non-rigid deformations. Those operators will be applied until the deviation between the CAD model and the acquired point cloud of the manufactured counterpart is minimized. During the deformation process, the topology of the CAD models will be preserved, to be able to maintain the whole coherency and possibly available semantic information. Based on these newly defined capabilities, it will also be possible to deform CAD models a priori, i.e. without any point cloud to serve as a reference and prior to the start of the manufacturing process or before a new manufacturing step, in order to compensate for future deviations and allow for first-time-right production. This will be made possible thanks to the use of a reinforcement learning strategy, wherein an autonomous agent will learn how to define the deformation sequence to be applied to compensate the coming shape deviations between the theoretical model and its manufactured counterpart. Following this strategy, it will therefore be possible to mix both known rules coming from existing machine fault modeling theories, as well as unknown rules to be learned from experience. The proposed framework will be implemented and validated on academic as well as industrial examples.

Required background: Computer science, geometric modeling, computer-aided design.

A list of 5 (max.) representative publications of the group:

Surleraux A., Pernot J-P., Elkaseer A., Bigot S., Iterative surface warping to shape craters in micro-EDM simulation, Engineering with Computers, vol. 32(3), pp. 517-531, 2016.
Surleraux A., Lepert R., Pernot J-P., Kerfriden P., Bigot S., Machine Learning-based reverse model-ling approach for rapid tool shape optimization in die-sinking micro Electro Discharge Machining, Journal of Computing and Information Science in Engineering, vol. 20(3), pp. 031002-1 à 11, 2020.
Shah G. A., Polette A., Pernot J-P., Giannini F., Monti M., Simulated annealing-based fitting of CAD models to point clouds of mechanical parts' assemblies, Engineering with Computers, vol. 37(4), pp. 2891-2909, 2021.
Peuzin-Jubert M., Polette A., Nozais D., Mari J-L., Pernot J-P., Survey on the View Planning Problem for reverse engineering and automated control applications, Computer-Aided Design, vol. 141, 103094, 2021.
Hu S., Polette A., Pernot J-P., SMA-Net: Deep learning-based identification and fitting of CAD models from point clouds, Engineering with Computers, 2022. https://doi.org/10.1007/s00366-022-01648-z

ParisTech

ESPCI PARIS PSL

TITLE: SELF-ASSEMBLED MOLECULAR LAYERS FOR PEROVSKITE SOLAR CELLS

Topic number : ***2022_060***

Field : Chemistry, Physical chemistry and Chemical Engineering, Energy, Processes, Material science, Mechanics and Fluids

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: Micro & Nano Characterization Group
http://optoelec.lpem.espci.fr
Research lab: LPEM - Laboratoire Physique et d'études des matériaux
Lab location: Paris
Lab website:http://www.lpem.espci.fr

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: CHEN Zhuoying zhuoying.chen@espci.fr
Advisor 2: Lang Philippe lang@univ-paris-diderot.fr
Advisor 3: Billot Laurent laurent.billot@espci.fr
Advisor 4:

Short description of possible research topics for a PhD: Solar cells, or photovoltaic devices, are one of the most promising solutions for replacing conventional fossil fuels in the fight against global warming. Among the various emerging “third-generation” solar cells, photovoltaic devices based on metal halide perovskites have attracted the attention of both the scientific and industry communities. Metal halide perovskites follow the crystallographic structure ABX3, where A is either an organic (methylammonium, MA or formamidinium, FA) or inorganic (Cs) cation, B is typically either Pb or Sn, and X is a halide anion (I, Br, Cl). Over the past few years, perovskite solar cells have shown a remarkable rise in their power conversion efficiencies (PCE), reaching a certified 25.5% after only a decade of research.
Despite the > 25% of PCE demonstrated in this type of solar cells in academic labs, much fundamental research and technological progress are still necessary before this technology can be implemented in large-scale. On one hand, by comparison to conventional silicon-base solar panels having a typical life-span of 25 years, unencapsulated perovskite solar cells suffer largely material and device instability due to the intrinsic material sensitivity to environmental factors (i.e. oxygen, water,

and light exposure). On the other hand, besides instability issues, some of the current state-of-the-art layers applied inside the perovskite solar cell device structures are highly costly. For example, the typical hole-transport layer, based on Spiro-MeOTAD costs more than 400 € per gram, while the typical compact electron transport layer based on TiO2 require an annealing of 500 °C. These energy-consuming and costly layers offset the potential cost-effective benefits of this technology.
In this PhD thesis, we propose to synthesis and investigate a series of self-assembly functional molecules and very thin self-assembled layers based on these molecules to replace one of the classical transport layers currently applied in perovskite solar cells. Examples of such a molecular route are shown in the figure below. These carefully designed and synthesized molecules, if successfully implemented into perovskite solar cells, will help to achieve multi-fold functions such as charge transport, moisture-repelling, and cost-reduction. Through this PhD thesis, the candidate will have a unique opportunity to learn and apply combined knowledge in organic synthesis, metal halide perovskite materials, photovoltaic devices, solar cell macroscopic and microscopic characterizations, together with various optical and spectroscopic techniques to investigate the fundamental roles of different molecular layers on device performance and stability.

Required background of the student: Solid academic background and a Master Degree on chemistry, material science, physics or applied physics. Good speaking & writing skills in English. Passionate in scientific experiments.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Enhancing the Efficiency and Stability of Triple-Cation Perovskite Solar Cells by Eliminating Excess PbI2 from the Perovskite/Hole Transport Layer Interface, Z. Hu et al., ACS Applied Materials & Interfaces, 12 (49), 54824-54832 (2020)

2. Luminescence enhancement effects on nanostructured perovskite thin films for Er/Yb-doped solar cells, Z. Hu et al., Nanoscale Advances 4 (7), 1786-1792 (2022)

3. Tailor-Made Amino-Based Self-Assembled Monolayers Grafted on Electron Transport ZnO Layers: Perovskite Solar Cell Performance and Modified Interface Relationship, H. Kouki et al., ACS Appl. Energy Mater. 5, 2, 1635–1645 (2022)

4. TiO2 Nanocolumn Arrays for More Efficient and Stable Perovskite Solar Cells, Z. Hu et al., ACS Applied Materials & Interfaces, 12 (5), 5979-5989 (2020)
5. Microscopic evidence of upconversion-induced near-infrared light harvest in hybrid perovskite solar cells, M. S. Sebag et al., ACS Applied Energy Materials, 1 (8), 3537-3543 (2018)

Illustrations :

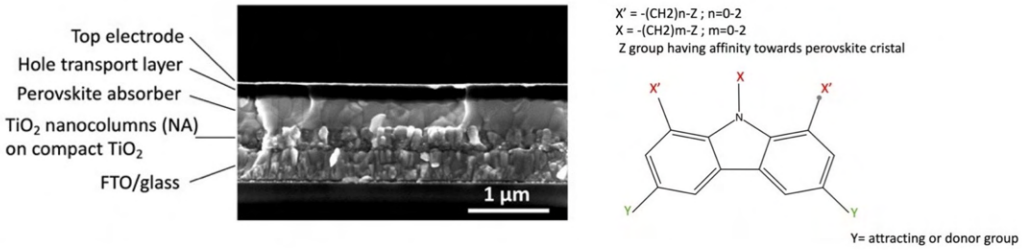


***Figure**: (Left) Cross-sectional SEM image of a typical triple-cation $Cs_{0.05}(FA_{0.83}MA_{0.17})_{0.95}Pb(I_{0.83}Br_{0.17})_3$ perovskite solar cell fabricated in our lab (LPEM) with a TiO_2 nanocolumn (NA) electron transport layer (ETL); (Right) Example of molecule structure developed in our lab (ITODYS) possibly capable to serve for both charge transport and stability enhancement functions.*

TITLE: HIGH SENSITIVITY ATOM INTERFEROMETRY USING MULTI-PHOTON INTERROGATION IN AN OPTICAL CAVITY

Topic number : ***2022_061***

Field : Physics, Optics, ,

Subfield: Atom Physics, Atom interferometry, Gravitational Waves

ParisTech School: Institut d'Optique Graduate School
Research team: Cold atoms in Bordeaux - MIGA team
https://www.coldatomsbordeaux.org/
Research lab: LP2N - Laboratoire Photonique, numérique et nanosciences
Lab location: Bordeaux
Lab website:https://www.lp2n.institutoptique.fr

Contact point for this topic: Institut d'Optique Graduate School

Advisor 1: Canuel Benjamin benjamin.canuel@institutoptique.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: This PhD project seeks to exploit the promising potential of large momentum transferring beam splitters to boost the sensitivity of atom interferometer based experiments and heralds a new class of applications in fundamental physics such as studies of Dark Matter or Gravitational Waves. This project relies on the potential of optical resonators as a key technique for sensitivity improvement. After the pioneering demonstration at LP2N of a matter wave interferometer in a 1 m marginally stable resonator, this PhD project will focus the development of such techniques on a gradiometric measurement configuration on a baseline of a few meters, a topic that will benefit from an atom gradiometer developed in the frame of the “MIGA project” at the LP2N laboratory. This PhD will focus on the study of different atom interferometry geometries using high-finesse resonators with the scope of demonstrating an improved measurement scale factor thanks to the use of the cavity. A specific configuration will be studied for future GW detectors based on matter-wave interferometry. This PhD project will also enable new applications for fundamental physics by extending atom gradiometry applications to the study of Dark

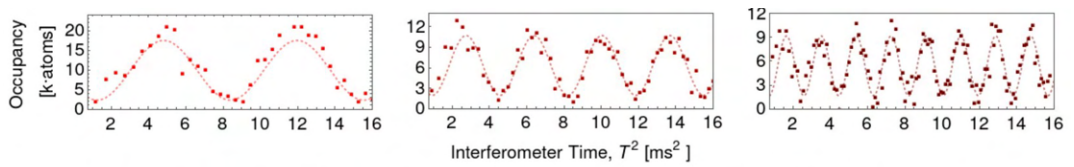
Matter. The use of an interrogation cavity could for example enable new parameter space studies for virialized ultralight field candidates.

Required background of the student: Optics, Atomic physics,

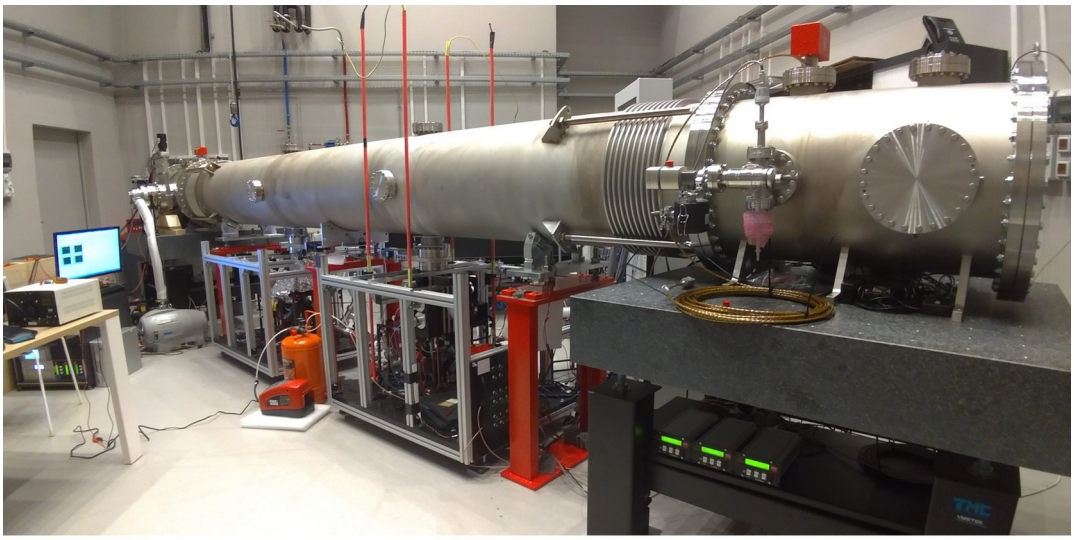
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. B. Canuel, A. Bertoldi, L. Amand et al. Exploring gravity with the MIGA large scale atom interferometer. Sci Rep 8, 14064 (2018). https://doi.org/10.1038/s41598-018-32165-z
2. D. O. Sabulsky, J. Junca, X. Zou, A. Bertoldi, M. Prevedelli, Q. Beaufils, R. Geiger, A. Landragin, P. Bouyer, B. Canuel, Multi-photon Atom Interferometry via cavity-enhanced Bragg Diffraction, arXiv:2201.11693 (2022), https://doi.org/10.48550/arXiv.2201.11693
3. B. Canuel, S. Abend, P. Amaro-Seoane, et al. ELGAR - a European Laboratory for Gravitation and Atom-interferometric Research, Class. Quantum Grav. 37 225017 (2020), https://doi.org/10.1088/1361-6382/aba80e
4. I. Riou, N. Mielec, G. Lefèvre, M. Prevedelli, A. Landragin, P. Bouyer, A. Bertoldi, R. Geiger, and B. Canuel, A marginally stable optical resonator for enhanced atom interferometry, J. Phys. B: At. Mol. Opt. Phys. 50, 155002 (2017), https://doi.org/10.1088/1361-6455/aa7592
5.

Illustrations :



First demonstration of **in cavity atom interferometry** using high order Bragg diffraction of the matter-waves on the resonating field. From left to right, interference patterns due to diffraction order of 1, 2 and 4. The reduction of the inter-fringe is linked to the increase of the scale factor of the measurement.



Atom gradiometer experiment at LP2N laboratory.

PhD proposal

High sensitivity Atom Interferometry using multi-photon interrogation in an optical cavity

Advisor: Canuel Benjamin, benjamin.canuel@institutoptique.fr

This PhD project seeks to exploit the promising potential of large momentum transferring beam splitters to boost the sensitivity of atom interferometer based experiments and heralds a new class of applications in fundamental physics such as studies of Dark Matter or Gravitational Waves. This project relies on the potential of optical resonators as a key technique for sensitivity improvement. Developments achieved by a few groups worldwide have recently led to multiple breakthroughs bought about by bespoke resonators designed for atom interferometry.

After pioneering results, obtained in the frame of "MIGA" project [1], with the demonstration of a matter wave interferometer in a 1 m marginally stable resonator [2] (see Fig. 1), this PhD project will focus the development of such techniques on a gradiometric measurement configuration on a baseline of a few meters. Based on the differential measurements from pairs of spatially separated atom interferometers interrogated within the same resonator, this configuration offers an important immunity to common noise sources and is therefore one of the main technological bricks to build future high sensitivity experiments, such as Gravitational Wave detectors.

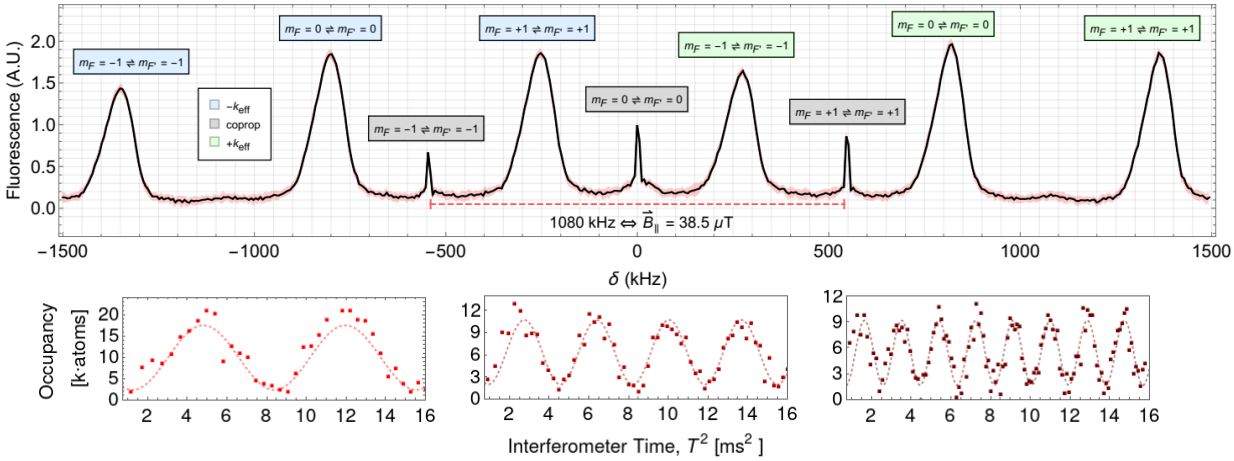


Figure 1: Atomic data. Top: Quantum state and momentum spectroscopy of the atoms on their ballistic flight toward the interrogation region. Bottom: Once inside the interrogation region, from left to right, interference patterns due to diffraction with 2, 4, and 8 photons.

The PhD project will benefit from an atom gradiometer (see Fig. 2) developed in the frame of the "MIGA project" at the LP2N laboratory. This setup is based on the use of cold atom sources of ^{87}Rb launched on a vertical trajectory towards an interrogation region where the resonating mode of horizontal cavities are used to create matter-waves interferometers in a (π/2)-(π)-(π/2) geometry.

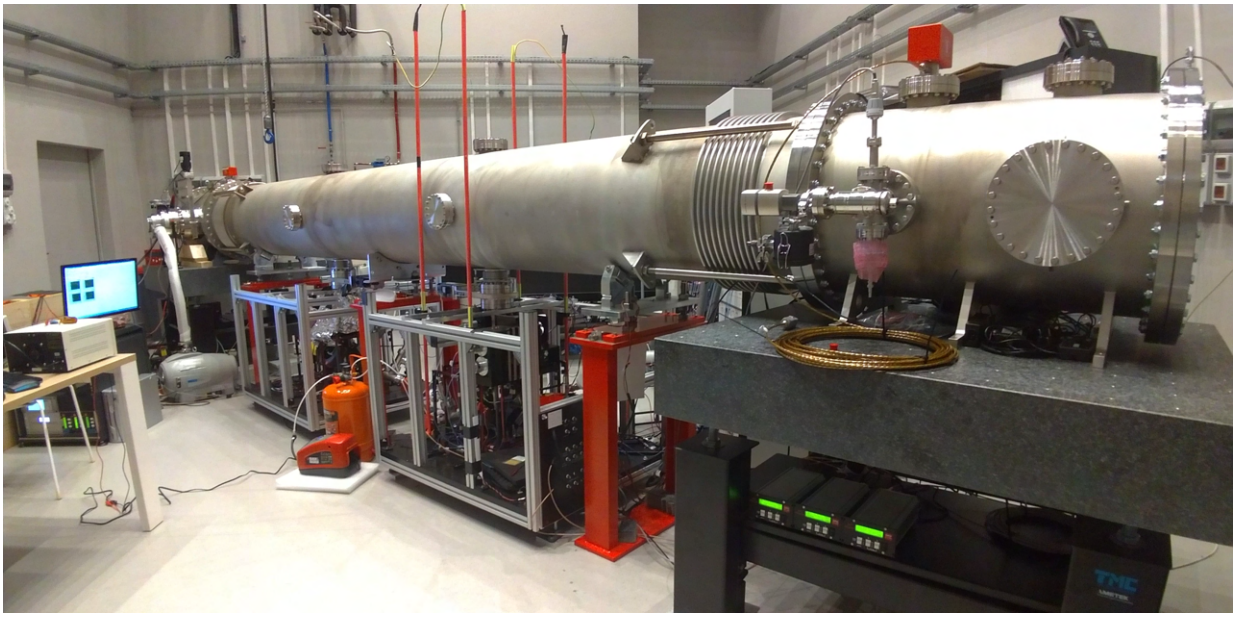


Figure 2: Atom gradiometer experiment at LP2N laboratory.

While cavities are now considered as disruptive tools to improve atom interferometer sensitivity, the efficiency of this method scales with resonator finesse, for both scale factor improvement and future implementation of sub shot-noise measurement schemes. This PhD will therefore focus on the study of different atom interferometry geometries using high-finesse resonators with the scope of demonstrating an improved measurement scale factor thanks to the use of the cavity. A specific configuration will be studied for future GW detectors based on matter-wave interferometry [3].

Based on such developments, the perspective for this PhD project is to enable new applications for fundamental physics by extending atom gradiometry applications to the study of Dark Matter. The use of an interrogation cavity could for example enable new parameter space studies for virialized ultralight field candidates.

[1] B. Canuel, A. Bertoldi, L. Amand et al. **Exploring gravity with the MIGA large scale atom interferometer**. Sci Rep 8, 14064 (2018). https://doi.org/10.1038/s41598-018-32165-z

[2] D. O. Sabulsky, J. Junca, X. Zou, A. Bertoldi, M. Prevedelli, Q. Beaufils, R. Geiger, A. Landragin, P. Bouyer, B. Canuel, **Multi-photon Atom Interferometry via cavity-enhanced Bragg Diffraction**, arXiv:2201.11693 [physics.atom-ph] (2022), https://doi.org/10.48550/arXiv.2201.11693

[3] B. Canuel, S. Abend, P. Amaro-Seoane, et al. **ELGAR - a European Laboratory for Gravitation and Atom-interferometric Research**, Class. Quantum Grav. 37 225017 (2020), https://doi.org/10.1088/1361-6382/aba80e

ParisTech

TITLE: ENHANCED PASSIVITY AND CORROSION RESISTANCE OF MULTI PRINCIPAL ELEMENT ALLOYS

Topic number : ***2022_062***

Field : Chemistry, Physical chemistry and Chemical Engineering, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team:
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location:
Lab website:https://www.ircp.cnrs.fr/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Mercier Dimitri dimitri.mercier@chimieparistech.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Multi principal element alloys (MPEA), also called high entropy alloys (HEA), is a new class of metallic alloys (first elaborated in 2004) having a great interest as engineering alloys. Their mechanical properties have been widely studied and currently a detailed approach of the design of these alloys (microstructure, composition) allows elaborating specific alloys with excellent mechanical properties, that may outperform those of conventional alloys. In contrast to the mechanical properties, the surface reactivity of these materials, and particularly their corrosion resistance, has only been slightly studied. Different studies have shown that the original “Cantor” alloy does not provide good corrosion resistance, due to its high (equimolar) Mn content. Combining what we know of the origin of the corrosion resistance of Ni and Fe-based stainless alloys, and applying a thermodynamic approach for the composition optimization, our research group was able to design and synthesize two new single-phase HEA/MPEA alloys containing molybdenum, which show excellent corrosion resistance.
The purpose of this research program is to understand the detailed relationship between alloy composition, surface reactivity and corrosion behavior (passivity, passivity breakdown, localized corrosion resistance)

of MPEA/HEA alloys with high Cr and Mo contents, and explore a range of compositions that can be maintained as single fcc phase after rapid cooling or contain Mo-rich secondary phases. The surface oxides (native and passive films), which are key factors for the corrosion resistance, will be characterized for the different alloy compositions by advanced surface analysis techniques, including X-ray Photoelectron Spectroscopy (XPS) and Time-of-Flight Secondary Ion Spectrometry (ToF-SIMS), combined with electrochemical measurements. A focus will be placed on the stability and the growth mechanisms of these layers using an original approach developed by our research group, using in situ isotopic labelling ($^{18}O_2$).

Required background of the student: Corrosion Science, Surface Science, Materials Science, Electrochemistry

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Enhanced passivity of Cr-Fe-Co-Ni-Mo multi-component single-phase face-centred cubic alloys: design, production and corrosion behaviour

Corrosion Science 200 (2022) 110233

2. Study of the surface oxides and corrosion behaviour of an equiatomic CoCrFeMnNi high entropy alloy by XPS and ToF-SIMS

Corrosion Science 167 (2020) 108507

3. Insight on passivity of high entropy alloys: Thermal stability and ion transport mechanisms in the passive oxide film on CoCrFeMnNi surfaces

Corrosion Science 188 (2021) 109540

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5.

Illustrations :

ParisTech

ESPCI PARIS PSL

TITLE: THE GLASS TRANSITION CHALLENGE TACKLED WITH NANO-COLLOIDS

Topic number : ***2022_063***

Field : Chemistry, Physical chemistry and Chemical Engineering, Material science, Mechanics and Fluids,

Subfield: Glass Transition, Colloids, Soft Matter

ParisTech School: ESPCI Paris - PSL
Research team: Paddy Royall http://www.padrus.com
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location: Paris
Lab website:https://www.gulliver.espci.fr/

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Royall Paddy paddy.royall@espci.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: It is a basic tenet of materials science that the macroscopic properties of a material are, ultimately, encoded in its structure at the microscopic level. Glasses challenge this viewpoint, as their microscopic structure closely resembles that of a liquid, yet they are as solid as any conventional crystalline solids. The reason the glasses are solid thus stands as a major outstanding question of condensed matter.

While the 2021 Nobel Prize in Physics was awarded to Giorgio Parisi in no small part for his work on the glass transition, Parisi's contribution pertains mainly to the glass transition in infinite dimension and it is fair to say that this is solved. However, in 3d the question remains wide open. In order to understand the underlying physical processes, it is necessary to obtain data at which the relaxation processes of the individual constituent particles can be observed and for this purpose, colloidal particles which behave just like atoms and molecules, yet are large enough to image using a microscope provide a means to reveal these relaxation processes - real space analysis.

As powerful as such real space analysis of colloidal particles is, it has an “Achilles heel”. The resolution of optical microscopes is limited to colloids of 1 micron in size or larger. Alas, such large colloids move quite slowly and thus very viscous glassy systems cannot be studied. The recent emergence of super–resolution “nanoscopy”, which seemingly defies the laws of optics, such as STimulated Emission via Depletion (STED) quite simply redefines the field of real space analysis of colloids (see attached Figures). This project explores the use of STED nanoscopy to tackle the glass transition with nano—colloids, in particular to probe the relaxation mechanisms in highly viscous glassy colloidal systems.

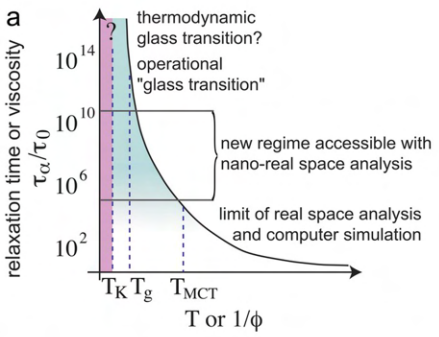
Reference: Hallett, J. E.; Turci, F. & Royall, C. P. “Local structure in deeply supercooled liquids exhibits growing lengthscales and dynamical correlations” Nature Comms. 9, 3272 (2018).

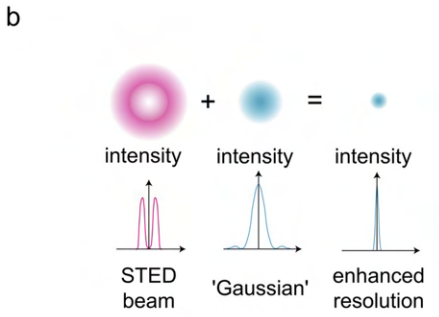
Required background of the student: Physics or Chermistry

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Hallett, J. E.; Turci, F. & Royall, C. P. “Local structure in deeply supercooled liquids exhibits growing lengthscales and dynamical correlations” Nature Comms. 9, 3272 (2018).
2. Royall, C. P. & Williams, S. R. "The role of local structure in dynamical arrest" Phys. Rep., 560, 1-75 (2015).
3. Hallett, J. E.; Turci, F. & Royall, C. P. "The devil is in the details: pentagonal bipyramids and dynamic arrest", J. Stat. Mech.: Theory and Experiment, 014001 (2020).
4.
5.

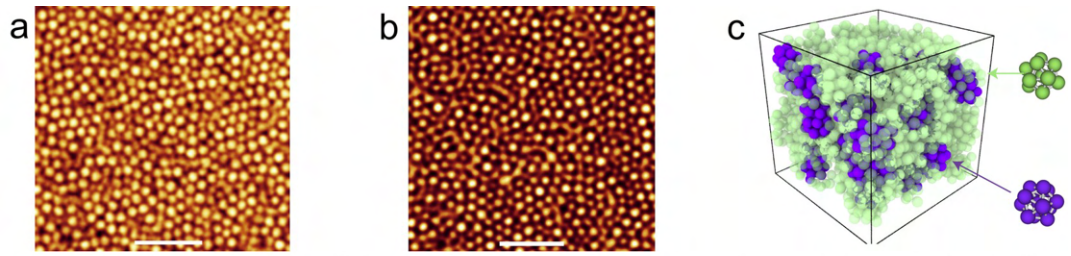
Illustrations :





The glass transition: the operational glass transition, T_g is the limit of experiments using molecules, some 14 decades in relaxation time slower than the normal liquid. This still does not reach the putative ideal glass transition at T_k (see text). Computer simulations and particle-resolved colloid experiments are hampered even further, as they are limited to only around 4 decades of change in relaxation time. Nano–real space analysis uses smaller colloids to access the timescales closer to T_g.

STED Nanoscopy: The resolution of a conventional confocal microscope is limited by diffraction, which determines the width of the imaging beam. (a) In the lateral (x, y) plane STED uses a "doughnut" shaped de-excitation beam which ensures that any excited fluorophore molecules return to the ground state via stimulated emission. Thus the only light detected comes from excited fluorophores in the centre of the doughnut, leading to super-resolution



Improved resolution using STED nanoscopy for particle–resolved studies of colloids. (a) Conventional real space analysis of 3000 nm diameter particles with confocal microscopy. Bar = 20 μm. (b) Proof–of–principle of nano–real space analysis of 580 nm diameter particles with STED. Bar = 2 μm. (c) Proof–of–principle of nano–real space analysis. Rendering of coordinates of of 580 nm diameter colloidal particles tracked using STED nanoscopy to identify higher–order structure. Particles rendered in green: 10–membered defective icosahedra. Particles rendered in purple: 13–membered full icosahedra. Identifying such higher–order correlations, which are thought to be crucial for phenomena such a the glass transition and crystal nucleation in very

ParisTech

TITLE: NOVEL GREEN ORGANIC INHIBITORS FOR THE CORROSION PROTECTION OF METALS AND ALLOYS

Topic number : ***2022_064***

Field : Chemistry, Physical chemistry and Chemical Engineering, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team:
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location:
Lab website:https://www.ircp.cnrs.fr/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Mercier Dimitri dimitri.mercier@chimieparistech.psl.eu
Advisor 2: Costa Dominique dominique.costa@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The durability of metals/alloys is a key towards a sustainable world. To this end, the use of organic molecules as corrosion inhibitors is of major interest for many industrial applications. The evolution of international regulations requires, for some applications, to reconsider the chemical nature of these molecules and find new environmentally friendly protective coatings.
Our research group is already investigating to a wide range of organic compounds (carboxylic acids, organosulfur…) on oxidized metals by an approach combining theoretical and experimental methods.
The purpose of this research program is to develop novel organic inhibitors based on the N heterocyclic carbene (NHC) chemistry. NHCs are used in many fields (organometallic chemistry, catalysis, nanoparticles synthesis) due to their strong interaction with a wide range of metals. Combined with an efficient functionalization, NHC could play an important role in the universal protection of metallic materials. Thus, we propose to understand the role of specific functionalized NHC on aluminium, copper, and aluminium alloys (Al 2024 particularly). A methodology combining DFT calculations, advanced surface characterization (XPS and ToF-SIMS) and surface reactivity

(electrochemical measurements, kinetic measurements assisted by quartz crystal microbalance) will be used to unravel the adsorption mechanisms of NHCs and the mechanisms of corrosion inhibition, and develop appropriate compositions for improved corrosion inhibition.

Required background of the student: Corrosion Science, DFT, Surface Science, Materials Science, Electrochemistry. Knowledge in organic chemistry will be appreciated.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Electrochemical, Surface-Analytical, and Computational DFT Study of Alkaline Etched Aluminum Modified by Carboxylic Acids for Corrosion Protection and Hydrophobicity

J. Electrochem. Soc. 166 (2019) C3131–C3146

2. DFT studies of 2-mercaptobenzothiazole and 2-mercaptobenzimidazole as corrosion inhibitors for copper

Corrosion Science 174 (2020) 108840

3. N-Heterocyclic carbene-stabilized gold nanoparticles with tunable sizes

Dalton Trans.,2018,47,6850–6859

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Illustrations :

TITLE: A DECISION AID SYSTEM BASED ON A DECENTRALIZED ARCHITECTURE TO FASTER THE MANAGEMENT OF HAZARDS OCCURRING UNDER PRODUCTION AND LOGISTICS SYSTEMS

Topic number : ***2022_065***

Field : Information and Communication Science and Technology, ,

Subfield: Industrial Engineering

ParisTech School: Arts et Métiers
Research team:
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Aix-en-Provence
Lab website:https://lispen.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Roucoules Lionel lionel.roucoules@ensam.eu
Advisor 2: YAHIA Esma esma.yahia@ensam.eu
Advisor 3: Klement Nathalie Nathalie.Klement@ensam.eu
Advisor 4:

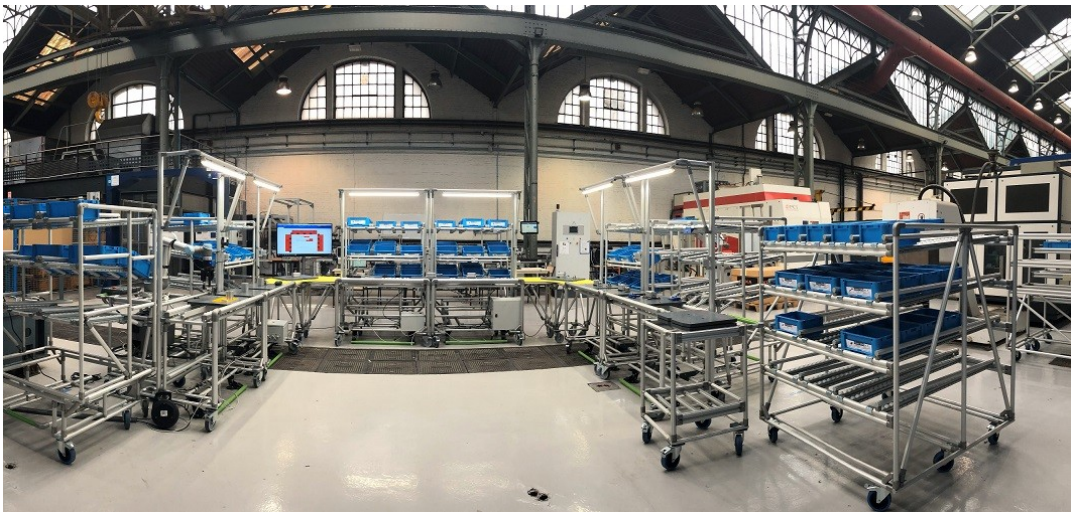
Short description of possible research topics for a PhD: In the context of to the Industry 4.0, production and logistics systems are becoming more and more connected which help to monitor the industrial processes in order to detect hazards and then react rapidly to manage them. The problematic we would like to address is how to manage information system continuity linking the factory, its suppliers, the resources (robots or human). Second, we aim to imply some work on the decentralized information system that presents different advantages when managing planning, scheduling, resources assignment, reaction to hazards. It should answer to how to deal with a missing operator, or with a lack of raw material? How to propagate the impact of this hazard into the scheduling or assignment which was supposed to be done on the current day. Different applications are available on our lab (Lille and Aix-en-Provence) so it would be the opportunity to implement on real case study the development of such decision aid system.

Required background of the student: Industrial engineering, Information system, operational research

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. 1. Amzil K., Yahia E., Klement N., Roucoules L. (2021) Causality Learning Approach for Supervision in the Context of Industry 4.0. In: Roucoules L., Paredes M., Eynard B., Morer Camo P., Rizzi C. (eds) Advances on Mechanics, Design Engineering and Manufacturing III. JCM 2020. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-030-70566-4_50
2. Beauville dit Eynaud, A., Klement, N., Roucoules, L. et al. Framework for the design and evaluation of a reconfigurable production system based on movable robot integration. Int J Adv Manuf Technol (2021). https://doi.org/10.1007/s00170-021-08030-1
3. Derigent, W., Cardin, O. & Trentesaux, D. Industry 4.0: contributions of holonic manufacturing control architectures and future challenges. J Intell Manuf 32, 1797–1818 (2021). https://doi.org/10.1007/s10845-020-01532-x
4. 4. Beauville dit Eynaud A., K. N. (2020). Risk and decision analysis for Reconfigurable Assembly System Design under uncertainties. 13th International Conference on Modeling, Optimization and Simuation-MOSIM'20-November 12-14, 2020 Agadir-Morocco" New advances and challenges for sustainable and smart industries"
5.

Illustrations :



ParisTech

TITLE: DEFORMATION MECHANISMS STUDY OF TWIP AND TRIP METASTABLE TITANIUM ALLOY

Topic number : ***2022_066***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team:
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location:
Lab website:https://www.ircp.cnrs.fr/la-recherche/equipe-ms/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Vermaut Philippe phlippe.vermaut@chimieparistech.psl.eu
Advisor 2: SUN Fan fan.sun@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Twinning induced plasticity (TWIP) and transformation induced plasticity (TRIP) effects are beneficial deformation mechanisms to enhance the mechanical properties of titanium alloys and enlarge their use to applications requiring specific combination of high strength and large homogeneous deformation before fracture. Metastable state of these Ti alloys allows various types of twinning and martensitic transformations to be operative under the application of external stress. This metastability can be controlled by the chemical composition and the microstructure (grain size, precipitation of a secondary phase, …). It has been recently shown in a previous PhD work that the TWIP and TRIP effects can be activated simultaneously or separately in the alloys with different structures and beta phase stability. An original method called Transformation Partition Mapping (TPM) has been developed in this PhD thesis to quantify the distribution of mechanical twinning and martensitic transformation as a function of grain orientation in different alloys with different metastability degree. The details of TPM method can be found in our recent publication “On the transformation pathway in TRIP/TWIP Ti–12Mo alloy”, Mater. Sci. Eng. A. 822 (2021).
Advanced in-situ characterizations in TEM under tensile deformation will be the second main method complimentary to in-situ EBSD statistics. The

research will focus on the clarification of fundamental mechanisms of the 332-type twinning, bcc orthorhombic martensitic transformation, their interaction with classic dislocation glide and the critical conditions necessary for their activation, on model beta metastable Ti alloys.
The thesis is projected for 48 months of experimental studies mainly at Métallurgie Structurale team of Chimie Paristech.

Required background of the student: Master level on material science and engineering or metallic materials ; basics in electron microscopy and biomaterials ; excellent English communication and writing, motivated in team-working and project-running.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. P. Kwasniak, F. Sun, S. Mantri, R. Banerjee, F. Prima, Polymorphic nature of \{332\} 113 twinning mode in BCC alloys, Mater. Res. Lett. (2022). https://doi.org/10.1080/21663831.2022.2049906.
2. B. Qian, M. Yang, L. Lilensten, P. Vermaut, F. Sun, F. Prima, In-situ observations of a hierarchical twinning–detwinning process in stress-induced α ″ -martensite of Ti-12Mo alloy, Mater. Res. Lett. 10 (2022) 45–51. https://doi.org/10.1080/21663831.2021.2013967.
3. B. Qian, L. Lilensten, J. Zhang, M. Yang, F. Sun, P. Vermaut, F. Prima, On the transformation pathway in TRIP/TWIP Ti–12Mo alloy, Mater. Sci. Eng. A. 822 (2021) 141672. https://doi.org/10.1016/j.msea.2021.141672.
4. B. Qian, J. Zhang, Y. Fu, F. Sun, Y. Wu, J. Cheng, P. Vermaut, F. Prima, In-situ microstructural investigations of the TRIP-to-TWIP evolution in Ti-Mo-Zr alloys as a function of Zr concentration, J. Mater. Sci. Technol. 65 (2021) 228–237. https://doi.org/10.1016/j.jmst.2020.04.078.
5. J. Zhang, Y. Fu, Y. Wu, B. Qian, Z. Chen, A. Inoue, Y. Wu, Y. Yang, F. Sun, J. Li, F. Prima, Hierarchical {332}<113> twinning in a metastable β Ti-alloy showing tolerance to strain localization, Mater. Res. Lett. 8 (2020) 247–253. https://doi.org/10.1080/21663831.2020.1745920.

Illustrations :

ParisTech

ESPCI PARIS PSL

TITLE: USING GOOD VIBRATIONS TO DECREASE THE VISCOSITY OF NON BROWNIAN SUSPENSIONS

Topic number : ***2022_067***

Field : Chemistry, Physical chemistry and Chemical Engineering, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: MIE https://www.mie.espci.fr/spip.php?page=unes&lang=fr
Research lab: CBI - Chimie, Biologie et Innovation
Lab location: Paris
Lab website:https://www.cbi.espci.fr/accueil-22/

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: COLIN Annie annie.colin@espci.fr
Advisor 2: Xiaoping Jia xiaoping.jia@espci.fr
Advisor 3: Tourin Arnaud arnaud.tourin@espci.fr
Advisor 4:

Short description of possible research topics for a PhD: Using good vibrations to decrease the viscosity of non brownian suspensions. Suspensions, which are dispersion of solid particles in a liquid are everyday objects: cement, particle suspensions for printing houses, polymer suspensions for 3D printing, polymer suspensions for forming coatings, carbon suspensions for preparing electrodes, mascara. The viscosity of the suspension increases until it becomes infinite when the concentration increases. To facilitate the flow of suspensions, it is possible to use formulations with surfactants or to use mechanical vibrations. Vibration has been used empirically in the industry for many years: vibrating conveyor belts for transporting dry granular materials, vibrating rulers or needles for evacuating air bubbles and leveling fresh concrete. Vibrations can also induce involuntary liquefaction of soils, as it was the case during the Nigata earthquake in Japan (see figure 1). However, the reasons for the action of vibrations are still poorly understood. In this thesis we will perform rheology measurements under ultrasound (frequency range 100 Khertz-600 Khertz) of model dispersions. These measurements will be completed by shear-reversal measurements to know if the contacts are broken or not in the flow, by

measurements of friction coefficient under vibration to know if it is modified by the vibrations, last but not the least avalanche effects will be studied. This will allow us to understand the action of ultrasound on dispersions. In the last year of the thesis, ultrasound will be added on a printing nozzle to facilitate the printing of suspensions.

Required background of the student: Rheology, soft matter

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Ovarlez G, Vu Nguyen Le A, Smit WJ, Fall A, Mari R, Chatté G, Colin A. Density waves in shear-thickening suspensions. Science advances. 2020 Apr 17;6(16):eaay5589.

2. Solvents govern rheology and jamming of polymeric bead suspensions

Nguyen Le, A.V., Izzet, A., Ovarlez, G., Colin, A.

Journal of Colloid and Interface Science, 2023, 629, pp. 438–450

3. Shear thickening in dense non-Brownian suspensions: Viscous to inertial transition

Madraki, Y., Oakley, A., Nguyen Le, A., ...Ovarlez, G., Hormozi, S.

Journal of Rheology, 2020, 64(2), pp. 226–237

4. Pairwise frictional profile between particles determines discontinuous shear thickening transition in non-colloidal suspensions

Comtet, J., Chatté, G., Niguès, A., ...Siria, A., Colin, A.

Nature Communications, 2017, 8, 15633

5.

Illustrations :

ParisTech

TITLE: HYDROMECHANICAL BEHAVIOR OF COMPACTED SAND-BENTONITE MIXTURE UNDER HYDRAULIC, GAS AND CHEMICAL LOADINGS

Topic number : ***2022_068***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Ecole des Ponts ParisTech
Research team:
Research lab: Laboratoire NAVIER (mécanique, physique des matériaux et des structures, géotechnique)
Lab location: Champs-sur-Marne
Lab website:https://navier-lab.fr

Contact point for this topic: Ecole des Ponts ParisTech

Advisor 1: Cui Yujun yu-jun.cui@enpc.fr
Advisor 2: Mokni Nadia nadia.mokni@irsn.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Bentonite sand mixtures have generally been envisaged as sealing materials for their high swelling capacity, low permeability and important radionuclides retardation capacities. The aim of this PhD study is to investigate the hydromechanical behavior of sand-bentonite mixtures with high sand content under hydraulic, gas and chemical loadings.
At the macroscopic scale, the following three aspects will be focused on:

(i) The swelling potential and swelling pressure of the high sand content mixture: decreasing the bentonite content might decrease the swelling potential of the mixture. This phenomenon is probably enhanced if the PH of the pore water increases.
(ii) Water permeability: increasing the sand proportion will probably induce the increase of the water permeability of the mixture. In addition, if dissolution of sand occurs under high pH, localized pathways might be generated, leading to the increase of advective water flow.
(iii) Gas permeability: under the conditions of high alkalinity and low bentonite content, further understanding of gas migration processes is required.
At the microscopic scale, particular attention must be paid to the capacity

of the bentonite to self-seal the possible pathways that might be created due to the dissolution of sand under alkaline exposure. For this purpose, the CT observation will be made on the material under alkaline environments.
The study is clearly oriented on the experimental approach. However, some preliminary modelling work will be carried out to enrich the PhD student capabilities. The objectives here, are to address some key phenomena involved in gas migration processes in case of the mixture hydrated by the reference low pH solution (Finite element code CODE_BRIGHT).

Required background of the student: Soil mechanics, laboratory testing

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. BARAKAT Y., CUI Y.J., MOKNI N. DELAGE P., BERNIER F. 2022. Effects of pH and exposure time to alkaline solutions on the mineralogy of the Opalinus Clay from the lower sandy facies of Mont Terri site. Engineering geology 306, 106766.
2. ZHANG Z., CUI Y.J., YANG J.W., MOKNI N., YE W.M., HE Y. 2022. Water retention and compression behaviours of MX80 bentonite pellet. Acta Geotechnica, online.
3. MOLINERO A., MOKNI N., CUI Y.J., DELAGE P., TANG A.M., AIMEDIEU P., BERNIER F., BORNERT M. 2020. Impact of initial structural heterogeneity on long-term swelling behavior of MX80 bentonite pellet powder mixtures. Canadian Geotechnical Journal, 57(9), 1404-1416.
4.
5.

Illustrations :

ParisTech

TITLE: INSTRUMENTAL AND METHODOLOGICAL DEVELOPMENTS FOR THE ON-LINE COUPLING OF MICROFLUIDIC CAPILLARY ELECTROPHORESIS TO SURFACE ENHANCED RAMAN SPECTROSCOPY (MCE-SERS) APPLIED TO THE SEPARATION AND IDENTIFICATION OF SUBMICO- AND NANOPLASTICS IN WATER

Topic number : ***2022_069***

Field : Chemistry, Physical chemistry and Chemical Engineering, Environment Science and Technology, Sustainable Development, Geosciences,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: SEISAD https://iclehs.fr/research/seisad/
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:https://iclehs.fr/

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: Varenne Anne anne.varenne@chimieparistech.psl.eu
Advisor 2: d'Orlyé Fanny fanny.dorlye@chimieparistech.psl.eu
Advisor 3: Trapiella Alfonso Laura
laura.trapiella@chimieparistech.psl.eu
Advisor 4:

Short description of possible research topics for a PhD: Submicro- and nanoplastics is an emerging topic of relevance in environmental science for they are ubiquitous, bioavailable and may present a high toxicity for biota and human being mainly due to their potential to cross biological membranes. There is a great analytical challenge in their detection since (i) existing protocols are mostly limited to particle size of a few micrometers and (ii) the few published strategies for the separation and identification of nanoplastics are multi-step analytical processes still suffering from a lack of accuracy and sensitivity. The PhD proposal aims to explore the benefits and risks brought by the development of a novel lab-on-a-chip device integrating microfluidic capillary electrophoresis and surface enhanced Raman spectroscopy (MCE-SERS) for the online separation and identification of submicro- and nanoplastics in water. Regarding the whole analytical process, the implementation of MCE offers potentiality for plastic preconcentration as well as separation into

fractions of specific size and surface chemistry, whereas SERS is a structurally descriptive and label-free detection method that will overcome the size limitation to microplastics detection and provide vibrational fingerprint spectra for plastic chemical identification. A dual-mode detection integrating fluorescence detection inline will be further investigated for a more accurate quantification of plastics at trace amount.

Required background of the student: physico-chemistry, analytical separation, spectroscopy detection; microfabrication

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. C. Schwaferts et al. / Trends in Analytical Chemistry 112 (2019) 52e65
2. A. Tycova et al. / J. Chromatogr. A 1541 (2018) 39–46
3. K. Kant / Biosensors 2018, 8, 62
4. A Tycova / Journal of Chromatography A, 1541 (2018) 39–46
5. F. d'Orlyé / Electrophoresis, 30 (2009) 2572-2582

Illustrations :

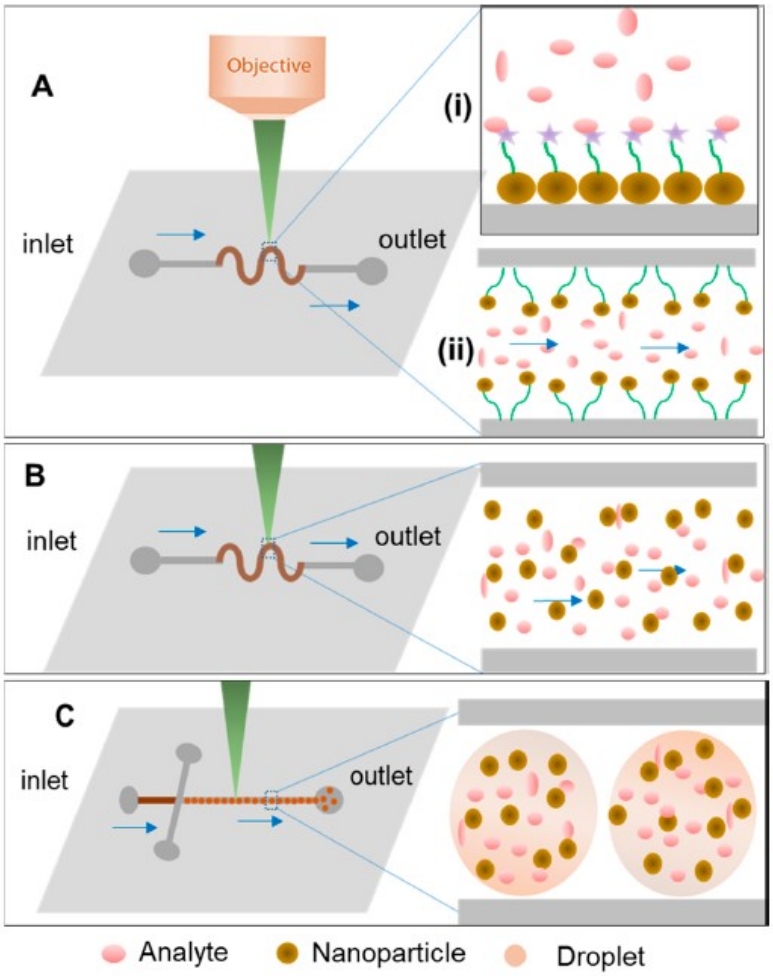


Figure 2. Schematic illustration of different strategies for lab-on-a-chip (LOC)-SERS devices; (**A**) immobilization of NPs in microfluidic channels in (i) static or (ii) continuous flow approach; (**B**) colloidal dispersions and continuous flow approach; and (**C**) in segmented flow.

ParisTech

Arts et Métiers

TITLE: DEVELOPMENT OF DATA-DRIVEN PHYSIC-GUIDED MODELLING METHODOLOGY FOR HYDROGEN ENERGY SYSTEMS

Topic number : ***2022_070***

Field : Energy, Processes, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LIFSE - Laboratoire Ingénierie des Fluides Systèmes Energétiques
Lab location: Paris
Lab website:https://lifse.artsetmetiers.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: DELIGANT Michaël michael.deligant@ensam.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Hydrogen energy has a major role in the energy transition and in the decarbonisation the energy and automotive industries. One of the most interesting way of using hydrogen is to convert it into electricy using a fuel cell. Proton exchange membrane fuel cell (PEMFC) and solid oxyde fuel cell (SOFC) are the two main available technologies. For an optimal operation, the fuel cell stack requires pressurised air and need to be maintained in a given range of thermal conditions. The design and control of thermal management systems and air loop components are thus crucial for maximizing the cell performances. Further improvements may be provided by waste heat recovery systems using available heat in the the exhaust or on the cooling loop.

The behavior of all the fluid and electrical components of fuel cell systems will be simulated using state of the art models availabe in the literature that will be implemented in MODELICA language or used from existing MODELICA librairies. The next step will be the implementation of surrogate models using different strategies such as Bayesian approaches or artifical neural network. Different levels of architecture decomposition and multi stacks systems will be investigated.

The two main objectives are
• perform systemic optimization of the components within the fuel system taking into account the transient behavior and components interactions

• search and optimize control strategies that maximize the electricity output and minimize the hydrogen consumption for considered use cases

Required background of the student: energy engineering, fluid mechanics, heat transfer

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Deligant, M. Huebel, T. Djaname, and F. Ravelet. Design and off-design system simulation of concentrated solar super-critical CO2 cycle integrating a radial turbine meanline model, Energy Reports, vol. 8, no. May, pp. 1381–1393, 2022, doi: 10.1016/j.egyr.2022.07.141.
2. R. Symes, T.-N. Djaname, M. Deligant, and E. Sauret, Design and optimization of a radial inflow turbine for use with a low temperature ORC. Energies, vol. 14, no. 24, 2021, doi: 10.3390/en14248526.
3. M. Deligant, E. Sauret, Q. Danel, and F. Bakir, “Performance assessment of a standard radial turbine as turbo expander for an adapted solar concentration ORC,” Renew. Energy, vol. 147, pp. 2833–2841, 2020, doi: 10.1016/j.renene.2018.10.019.
4. M. Specklin, M. Deligant, P. Sapin, M. Solis, M. Wagner, C. N. Markides, F. Bakir. Numerical study of a liquid-piston compressor system for hydrogen applications. Appl. Therm. Eng., vol. 216, 2022, doi:10.1016/j.applthermaleng.2022.118946.
5. M. Hübel, N. Nirmala, M. Deligant, L. Li. Hybrid physical-AI based system modeling and simulation approach demonstrated on an automotive fuel cell. 2022 Modelica Asian Conference

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: DESIGN A SAFE WORK-CELL FOR HUMAN-ROBOT CO-ACTIVITY IN INDUSTRY

Topic number : ***2022_071***

Field : Design, Industrialization, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: RAHARIJAONA Thibaut thibaut.raharijaona@univ-lorraine.fr
Advisor 2: KOESSLER Adrien adrien.koessler@univ-lorraine.fr
Advisor 3: STIEF Paul paul.stief@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD:
Collaboration between a human operator and a robot is a key feature of the “industry of the future”. The increasing interactions between humans and robots raise questions in terms of occupational risk prevention. For instance, how can we ensure, at the earliest stage of a work-cell design, that protective devices are properly chosen and placed at the appropriate safety distances? The overall aim of the thesis is to develop a methodological approach to identify the hazardous zones and to model and simulate the work-cell for real-time reconfiguration with a digital twin. Conventional design methods rely on the “worst-case hypothesis” given by the robot manufacturer
to implement safety equipment and strategies. These methods often lead to over-evaluation of the safety criteria, typically an overestimated breaking distance, which drastically reduces the system performance. We need to know how to combine robot performance and human safety in a cobotic cell.

Required background of the student: Mechanical Engineering, Robotic modeling and control, Sensor implementation

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Stief, P., Etienne, A., Dantan, J. Y., & Siadat, A. (2022). A methodology for production system design driven by product modelling and analysis–application in the automotive industry. International Journal of Production Research, 1-17.
2. P. Martin, B. Daille-Lefèvre, J. Marsot, X. Godot, G. Abba, A. Siadat, and M. Gomez-Echeverri. “New Issues for Workers Safety in the Factory of the Future.” In Advances on Mechanics, Design Engineering and Manufacturing II, 402–11, 2019.
3. B. Tahar-Hakim, M. Bounouar, R. Bearee, and A. Siadat. “Industry of the Future, Future of Work: The Case of Collaborative Robotics.” In Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021), 29–35, 2021.
4.
5.

Illustrations :

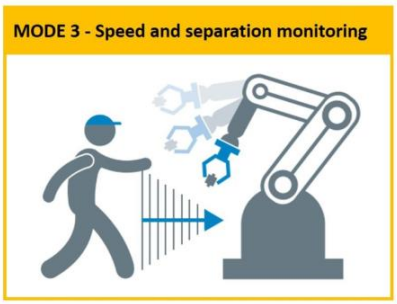
ParisTech

Arts et Métiers Sciences et Technologies

LCFC Conception Fabrication Commande

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Design, Industrialization
Title: **Design a safe work-cell for human-robot co-activity in in**



ParisTech School: Arts et Métiers Sciences et Technologies

Advisor(s) Name: Pr. Thibaut RAHARIJAONA, Dr. Adrien KOESSLE
Advisor(s) Email: thibaut.raharijaona@univ-lorraine.fr, adrien.koessler@u
paul.stief@ensam.eu

Research group/Lab: Laboratoire de Conception, Fabrication, Comm
(http://lcfc.ensam.eu)
Lab location: Metz - France

Short description of possible research topics for a PhD:
Collaboration between a human operator and a robot is a key feature of the "industry of the future". The increasing interactions between humans and robots raise questions in terms of occupational risk prevention.
For instance, how can we ensure, at the earliest stage of a work-cell design, that protective devices are properly chosen and placed at the appropriate safety distances?
The overall aim of the thesis is to develop a methodological approach to identify the hazardous zones and to model and simulate the work-cell for real-time reconfiguration with a digital twin.

Conventional design methods rely on the "worst-case hypothesis" given by the robot manufacturer to implement safety equipment and strategies. These methods often lead to over-evaluation of the safety criteria, typically an overestimated breaking distance, which drastically reduces the system performance.
We need to know how to combine robot performance and human safety in a cobotic cell.
The thesis aims at:

(i) **Identifying the potential hazardous zones** according [1] to the manufacturing task (robot trajectory, external loading, etc), in order to optimize the placements of safety equipment.
(ii) **Developing the perception** of the human presence in the shared work-cell by sensor implementation (eg. with a depth camera and/or distance sensors), and adapting the robot's control strategy accordingly.
(iii) **Reconfiguring in real-time** the work-cell by using a digital twin of the human-robot system updated by perception (sensors). We will adapt the robotic task with regards to safety and human factors.

We will validate the design method on robots working in a real industrial scenario (see also https://www.ant-technologie.fr/)

Required background of the student:
Robotic modeling and control, Sensor implementation, Mechanical engineering

A list of representative publications of the group:
[1] Stief, P., Etienne, A., Dantan, J. Y., & Siadat, A. (2022). A methodology for production system design driven by product modelling and analysis–application in the automotive industry. International Journal of Production Research, 1-17.
[2] P. Martin, B. Daille-Lefèvre, J. Marsot, X. Godot, G. Abba, A. Siadat, and M. Gomez-Echeverri. "New Issues for Workers Safety in the Factory of the Future." In Advances on Mechanics, Design Engineering and Manufacturing II, 402–11, 2019.
[3] B. Tahar-Hakim, M. Bounouar, R. Bearee, and A. Siadat. "Industry of the Future, Future of Work: The Case of Collaborative Robotics." In Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021), 29–35, 2021.

ParisTech

Arts et Métiers

TITLE: VERY-HIGH-CYCLE FATIGUE STRENGTH OF METALS UNDER MULTIAXIAL STRESS STATE

Topic number : ***2022_072***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: Fatigue of Materials and Structures https://www.i2m.u-bordeaux.fr/Recherche/DuMAS-DUrabilite-des-Materiaux-et-des-ASsemblages
Research lab: I2M - Institut de Mécanique et d'ingénierie
Lab location: Bordeaux
Lab website:https://www.i2m.u-bordeaux.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: PALIN-LUC Thierry thierry.palin-luc@ensam.eu
Advisor 2: BONNERIC Matthieu Matthieu.BONNERIC@ensam.eu
Advisor 3: HONG Youshi hongys@imech.ac.cn
Advisor 4: QIAN Guian qianguian@imech.ac.cn

Short description of possible research topics for a PhD: The design of safe components capable to endure a very high number of loading cycles: 1E9 cycles and more, is a very important challenge for engineers in oder to guaranty very long life of products. If the fatigue strength of components can now be simulated up to 1E7 cycles under complex loadings that are representative of real multiaxial loadings and stress states, this is not the case in the gigacycle regime (1E9 cycles and more). Indeed, since the end of the last century it is known that there is no infinite fatigue life of metals. The crack initiation mechanisms are more and more understood under uniaxial loadings (tension, bending) and a few models only have been published to assess the fatigue strength of metals under such loadings in the gigacycle regime. But there is nothing published under multiaxial loadings that are representative of real load cases of components.
A few ultrasonic fatigue testing machine have been recently developed in our team to test metallic specimens under torsion or under biaxial bending. A quite comprehensive study on very-high-cycle fatigue of different materials has also been performed in our team. The aim of this PhD is to study the gigacycle fatigue strength of two metallic alloys (an

aluminum one and a steel) under uniaxial (tension) and multiaxial (torsion and biaxial bending). The crack initiation and early crack growth mechanisms will be studied to propose a fatigue criterion capable to compute the very-high-cycle fatigue strength under multiaxial loadings.

Required background of the student: Solid mechanics, Mechanical engineering, Material science, Material physics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. A. Nikitin, T. Palin-Luc, A. Shanyavskiy (2016) Crack initiation in VHCF regime on forged titanium alloy under tensile and torsion loading modes, International Journal of Fatigue, Vol. 93, pp. 318–325.
2. C. Brugger, T. Palin-Luc, P. Osmond and M. Blanc (2017) A new ultrasonic fatigue testing device for biaxial bending in the gigacycle regime, Internation Journal of Fatigue, vol. 100, pp. 619 – 626.
3. A. Banvillet, T. Palin-Luc and S. Lasserre (2003) A volumetric energy based high cycle multiaxial fatigue criterion. Int. Journal of Fatigue, Vol. 25, pp. 755-769.
4. G. Qian, C. Zhou and Y. Hong (2015) A model to predict S–N curves for surface and subsurface crack initiations in different environmental media, Int. J. Fatigue, Vol. 71, pp. 35-44.
5. G. Qian, C. Zhou and Y. Hong (2011) Experimental and theoretical investigation of environmental media on very-high-cycle fatigue behavior for a structural steel, Acta Materialia, Vol. 59, pp. 1321-1327.

Illustrations :

ParisTech

MINES PARIS | PSL

TITLE: MODELLING AND OPTIMIZATION OF MEMORY ACCESSES ON MULTI-LEVEL MEMORY PARALLEL CPUS

Topic number : ***2022_073***

Field : Information and Communication Science and Technology, ,

Subfield:

ParisTech School: Mines Paris - PSL
Research team:
Research lab: CRI - Centre de recherche en informatique
Lab location: Fontainebleau
Lab website:https://www.cri.ensmp.fr/

Contact point for this topic: Mines Paris - PSL

Advisor 1: TADONKI Claude claude.tadonki@mines-paristech.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The significant advances in computer hardware related to multicore CPU that have occurred during the last two decades have been followed by an increasing complexity of the associated memory systems. A typical modern supercomputer is made up with multicore nodes that are locally coupled with common accelerators like the GPUs. In most of real-life applications, the memory access pattern does not naturally follow the ideal flow expected for a memory optimal implementation. Thus, in order to lower the overhead due to memory activities, we need a deep understanding of the critical aspects that may lead to performance degradation. A common example is how concurrent memory accesses affect scalability on a multicore system, especially on large-scale ones. Another point is the need for a good cost prediction model for the memory accesses and a good memory optimization methodology. For current and future many-core processors, a special attention should be paid on non-uniform-accesses (NUMA) memory. The purpose of this thesis is to investigate these two aspects by means of meaningful illustrations, careful benchmarks, mathematical modeling and optimization methodologies.

Required background of the student: Computer Science, Applied Mathematics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. T. Saidani, L. Lacassagne, J. Falcou, C. Tadonki, Samir Bouaziz, Parallelization Schemes for Memory Optimization on the Cell Processor: A Case Study on the Harris Corner Detector, Transactions on High-Performance Embedded Architectures and Compilers, volume 3 (3) 2011, pp. 177-200, 4/1/2011.

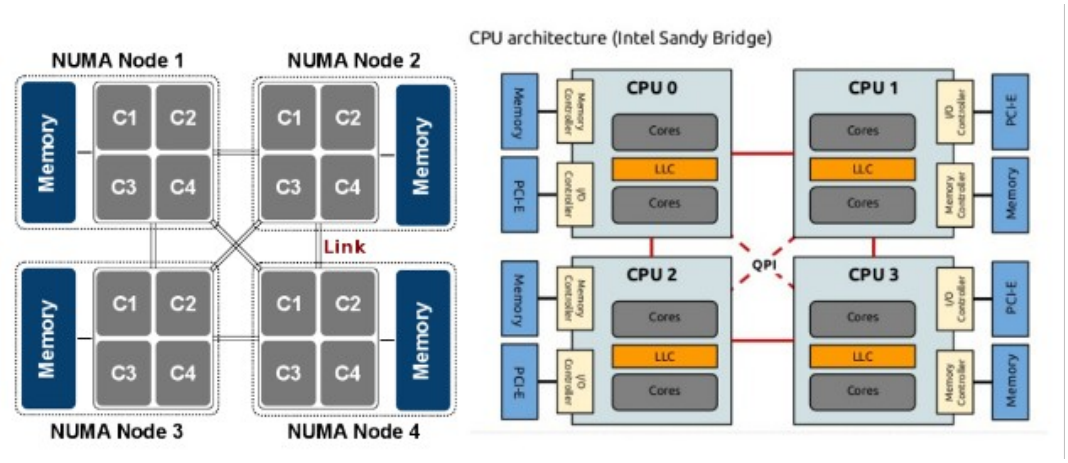
2. François Irigoin, Tiling, chapter in Encylopedia of Parallel Computing, David Padua Editor-in-Chief, Springer-Verlag, 2011, pp. 2040-2049 ISBN 978-0-387-09765-7, Année 2011.

3. Claude Tadonki, O. Haggui, C. Tadonki, L. Lacassagne, F. Sayadi, B. Ounid, Harris Corner Detection on a NUMA Manycore, Future Generation Computer Systems (DOI: 10.1016/j.future.2018.01.048), 2018.

4. Claude Tadonki, C. Tadonki, Scalable NUMA-Aware Wilson-Dirac on Supercomputers,
International Conference on High Performance Computing & Simulation (HPCS 2017), Genoa, Italy, July 17-21, 2017.

5.

Illustrations :



ParisTech

TITLE: RADICAL ARYLATIONS FOR THE PRODUCTION OF ACTIVE PHARMACEUTICAL INGREDIENTS IN BATCH AND FLOW MECHANOCHEMISTRY

Topic number : ***2022_074***

Field : Chemistry, Physical chemistry and Chemical Engineering, Life and Health Science and Technology,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Catalysis, Synthesis of Biomolecules and Sustainable Development Team (CSB2D) https://www.lenresearch.com
Research lab: I-CLEHS - Institute of chemistry for life and health
Lab location: Paris
Lab website:https://iclehs.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: LEN CHRISTOPHE christophe.len@chimieparistech.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Among the ubiquitous pharmacophores, benzene and (hetero)aryl rings are the most encountered substituents in drugs. Thus, these pharmacophores constitute attractive molecular building blocks in medicinal chemistry. Among the possible approaches to introduce a (hetero)aryl, radical reactions are an interesting approach. The main objective of the project will be to exploit the synthetic power of radical reactions to introduce (hetero)aromatic substituents into molecules in a racemic and enantioselective manner from non-halogenated compounds. The proof of concept will be realized using traditional batch chemistry and, in order to reduce waste and/or the use of solvents, the reactions will be transposed in ball-milling in the presence of transition metals and/or only piezo-electric catalysts and then transpose into continuous flow mechanochemistry for scale-up, these two last techniques being alternative energies to have environmentally friendly processes.

Required background of the student: Organic chemistry, catalysis, continuous flow, mechanochemistry

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. E. Vitaku, D.T. Smith, J.T. Njardarson, Analysis of the structural diversity, substitution patterns, and frequency of nitrogen heterocycles among U.S. FDA approved pharmaceuticals, J. Med. Chem. 2014, 57, 10257-10274.

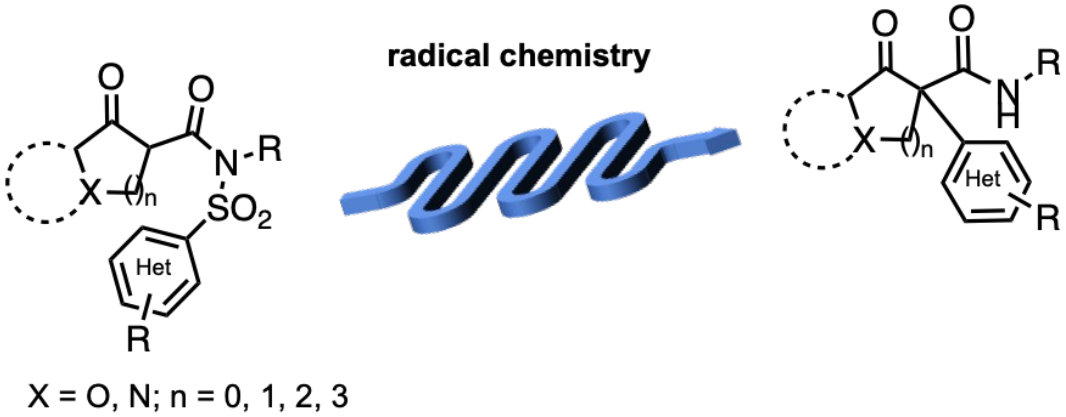
2. R.D. Taylor, M. MacCoss, A.D.G. Lawson, Rings in drugs, J. Med. Chem. 2014, 57, 5845-5959.

3. N. Gillaizeau-Simonian, E. Barde, A. Guérinot, J. Cossy, Cobalt-catalyzed 1,4-aryl migration/desulfonylation cascade: synthesis of □-aryl amides, Chem. Eur. J. 2021, 27, 4004-4008.

4.

5.

Illustrations :



ParisTech

Arts et Métiers Sciences et Technologies

TITLE: DIRECT NUMERICAL SIMULATION (DNS) OF OIL/WATER FLOWS REPRESENTATIVE OF OIL SPILLS

Topic number : ***2022_075***

Field : Material science, Mechanics and Fluids, Life Science and Engineering for Agriculture, Food and the Environment, Environment Science and Technology, Sustainable Development, Geosciences

Subfield: Fluid Mechanics

ParisTech School: Arts et Métiers
Research team:
Research lab: LMFL - Laboratoire de mécanique des fluides de Lille
Lab location: Lille
Lab website:http://lmfl.cnrs.fr/en/home/

Contact point for this topic: Arts et Métiers

Advisor 1: Coutier-Delgosha Olivier olivier.coutier-delgosha@ensam.eu
Advisor 2: Bayeul-Lainé Annie-Claude annie-claude.bayeul-laine@ensam.eu
Advisor 3: Simonet Sophie sophie.simonet@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: After the Deepwater Horizon accident in the Gulf of Mexico in 2010, large funding has been mobilized for research activities devoted to oil spills and their effects. One question is about the interaction between the see water and the oil slicks and how the oil is mixed with the water and the atmosphere (creation of aerosols). Several experiments were conducted at Johns Hopkins university, including for example an oil plume at the bottom of a tank, with a water cross flow, or a rain drop falling on a water tank with oil slick at the surface, to mimic the effects of rain at the surface of the ocean, and oil slick at the surface of water in a wave tank. In the two first configurations, CFD has been already started at Arts et Metiers ParisTech. It is based on Direct Numerical Simulations of the oil/water/air mixture using the VOF (Volume of Fluid) approach available in the BASILISK code. The PhD will be focused on the continuation of the existing activities: the challenge now is to capture the details of the small-scale oil dispersion, especially the micro and nano droplets that are aerosolized in the air when dispersant is added to the oil, and the impact of the chemicals on these aspects. This last point is of primary interest for

public health issues. The results will be validated by comparison with the experimental data obtained at JHU, and further investigation of the numerical results will enable to better characterize the small-scale mechanisms involved in the unsteady evolution of the oil/water/air mixture.

Required background of the student: Fluid Mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. M. Ghandour, O. Coutier-Delgosha, D. Murphy & J. Katz (2016), Direct numerical modelling of raindrop impacting oil slicks, Presentation at the Gulf of Mexico Conference.
2. Hui WANG, Shuo LIU, Annie-Claude BAYEUL-LAINÉ, Olivier COUTIER-DELGOSHA (2022), Dynamics of high-speed drop impact on deep liquid pool, Proceedings of the Conference on Modelling Fluid Flow (CMFF'22), The 18th International Conference on Fluid Flow Technologies, Budapest, Hungary, August 30-September 2, 2022
3. Shuo LIU, Hui WANG, Annie-Claude BAYEUL-LAINÉ, Olivier COUTIER-DELGOSHA (2022), Direct numerical simulations of breaking waves, Proceedings of the Conference on Modelling Fluid Flow (CMFF'22), The 18th International Conference on Fluid Flow Technologies, Budapest, Hungary, August 30-September 2, 2022
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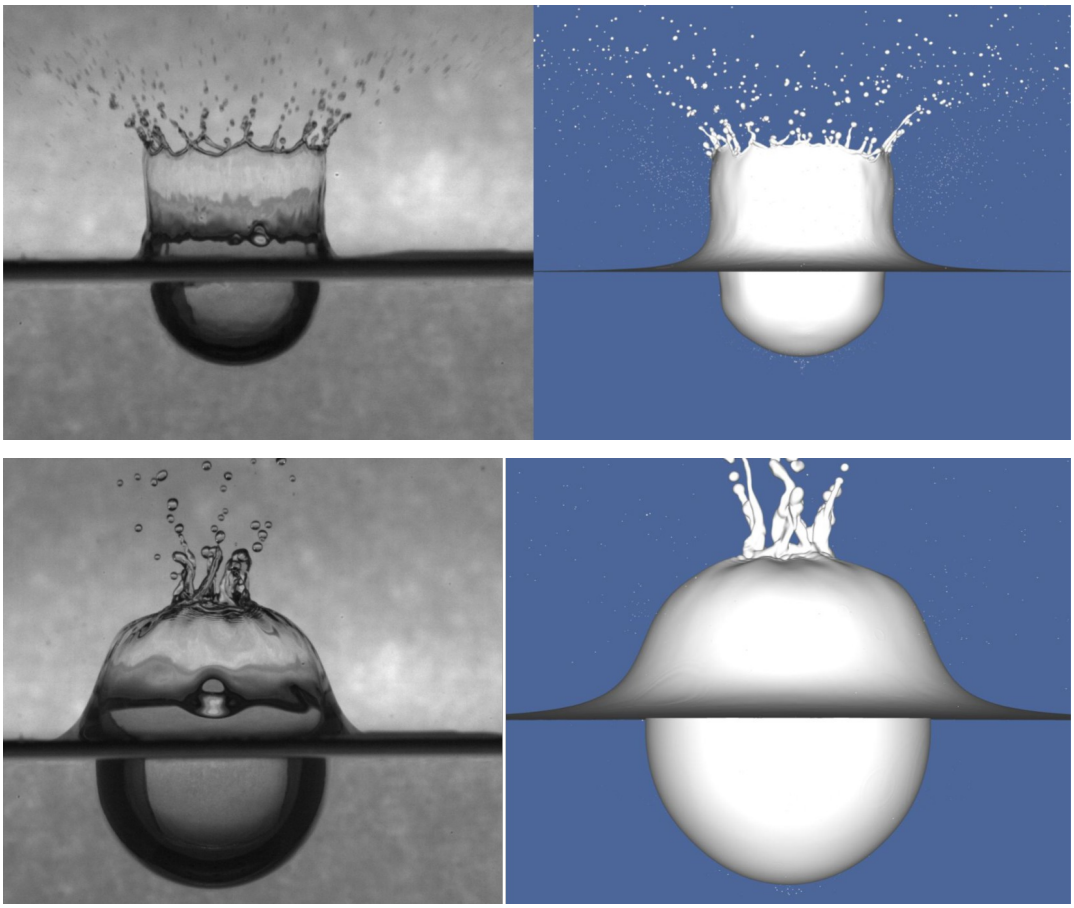
Illustrations :



ParisTech

Arts et Métiers Sciences et Technologies

TITLE: DIRECT NUMERICAL SIMULATION (DNS) OF BUBBLE BURSTING

Topic number : ***2022_076***

Field : Material science, Mechanics and Fluids, Life Science and Engineering for Agriculture, Food and the Environment, Environment Science and Technology, Sustainable Development, Geosciences

Subfield: Fluid dynamics

ParisTech School: Arts et Métiers
Research team:
Research lab: LMFL - Laboratoire de mécanique des fluides de Lille
Lab location: Lille
Lab website:http://lmfl.cnrs.fr/en/home/

Contact point for this topic: Arts et Métiers

Advisor 1: Coutier-Delgosha Olivier olivier.coutier-delgosha@ensam.eu
Advisor 2: Bayeul-Lainé Annie-Claude annie-claude.bayeul-laine@ensam.eu
Advisor 3: Simonet Sophie sophie.simonet@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Bubbles are ubiquitous in nature and industry, and bubble bursting is a widely studied and highly important physical process. Marine aerosol droplets ejected into the air during bubble bursting play an important role in climate processes by acting as cloud condensation nuclei and by scattering radiation. Much of the early work on the fluid dynamics of bubble bursting was motivated by a desire to understand the mechanisms of marine aerosol production and to determine the size distributions of produced droplets. It has been found that three processes, namely film rupture and retraction, droplet production, and gas escape occur during bubble bursting. This project will be focused on the escaping gas and on how it may interact with and transport droplets away from the air-water interface and up into the atmosphere. The objective is to investigate by Direct Numerical Simulation (DNS) the gas jet released by bubbles bursting at the air-sea interface and the capacity of this flow to transport newly formed film droplets up into the atmosphere. For that purpose, the open-source BASILISK code, using octree adaptive grid refinement and advanced VOF (Volume of Fluid) methods for interface reconstruction, will be applied. Both single bubble bursting and multiple bubble bursting

will be studied: bubbles often join together to form bubble rafts or foams, and the effect of such structures on bubble bursting behavior, formation of aerosol droplets, and ejection of a gas jet or vortex ring is largely unknown. The question of how bubble rafting affects the collective gas flow of multiple bubbles bursting at the air-water interface will thus be addressed.

Required background of the student: Fluid mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Dasouqi, A. A., Yeom, G. S., & Murphy, D. W. (2021). Bursting bubbles and the formation of gas jets and vortex rings. Experiments in Fluids, 62(1), 1-18.

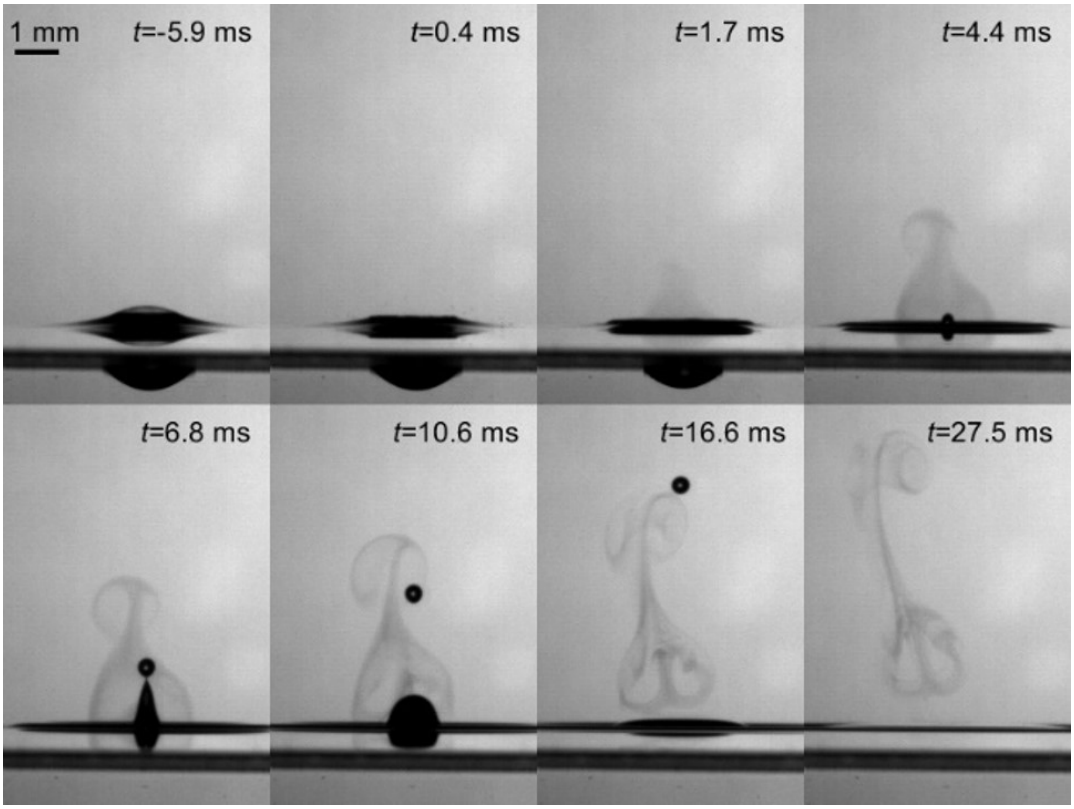
2. Dasouqi, A. A., Ghossen, J., & Murphy, D. W. (in press). The Effect of Liquid Properties on the Release of Gas from Bursting Bubbles.

3. Dasouqi, A. A., & Murphy, D. W. (2020). Gas escape behavior from bursting bubbles. Physical Review Fluids, 5(11), 110502.

4.

5.

Illustrations :



ParisTech

INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech | université PARIS-SACLAY

TITLE: COHERENT MANIPULATION OF ENTANGLED EMITTERS

Topic number : ***2022_077***

Field : Physics, Optics, ,

Subfield: Quantum optics

ParisTech School: Institut d'Optique Graduate School
Research team: Nanophotonics https://bordeaux-nanophotonics.fr/news-and-events/
Research lab: LP2N - Laboratoire Photonique, numérique et nanosciences
Lab location: Bordeaux
Lab website:https://www.lp2n.institutoptique.fr/

Contact point for this topic: Institut d'Optique Graduate School

Advisor 1: LOUNIS Brahim brahim.lounis@u-bordeaux.fr
Advisor 2: TREBBIA Jean-Baptiste jean.baptiste.trebbia@u-bordeaux.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The control and manipulation of entangled quantum states are crucial for the development of quantum technologies. One promising approach is to couple quantum light emitters trapped in a transparent solid via their coherent optical dipole-dipole interactions. The realization of entangled quantum states in condensed matter is in itself a challenge, as it requires finding nano-emitters that are both spatially neighboring at the nanoscale and spectrally nearly identical. Thanks to an innovative super-resolved imaging technique that we have developed in the laboratory , we have been able to identify coupled emitters and show that we can reach the maximum entanglement regime with the production of states close to Bell states .
The possibility to entangle or disentangle electronic states on demand opens the way to many applications in quantum optics, in particular the realization of quantum logic gates. In this thesis, we propose to perform such quantum operations at the sub-nanosecond scale on these delocalized quantum systems.
Yang, B., Trebbia, JB., Baby, R. et al. Optical nanoscopy with excited state saturation at liquid helium temperatures. Nature Photon 9, 658–662 (2015).

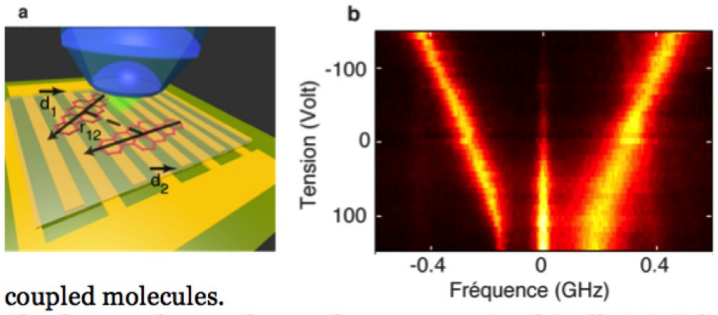
J.-B. Trebbia et al. Tailoring the superradiant and subradiant nature of two coherently coupled quantum emitters. Nat Commun 13, 2962 (2022).

Required background of the student: Quantum Physics, Quantum optics, Nanophysics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. J.-B. Trebbia et al. Tailoring the superradiant and subradiant nature of two coherently coupled quantum emitters. Nat Commun 13, 2962 (2022).
2. « 3D optical nanoscopy with excited state saturation at liquid helium temperatures », J.-B. Trebbia, R. Baby, P. Tamarat, and B. Lounis, Optics Express, 27 (2019) 23486
3. J.-B. Trebbia et al. Tailoring the superradiant and subradiant nature of two coherently coupled quantum emitters. Nat Commun 13, 2962 (2022).
4.
5.

Illustrations :



(a) A naphthalene crystal doped with fluorescent molecules is placed above a comb of electrodes and imaged with a microscope objective. (b) Anti-crossing of the electronic levels of two coupled molecules.
The degree of entanglement becomes maximal (Bell states) for an electric voltage of 150 Volts, with the onset of a two-photon transition as a signature of the coherent coupling of the two emitters.

TITLE: QUANTUM OPTICS WITH PEROVSKITE SINGLE NANOCRYSTALS AND SUPERLATTICES

Topic number : ***2022_078***

Field : Physics, Optics, ,

Subfield: Nano-optics, Condensed matter, quantum optics

ParisTech School: Institut d'Optique Graduate School
Research team: Nanophotonics https://bordeaux-nanophotonics.fr/news-and-events/
Research lab: LP2N - Laboratoire Photonique, numérique et nanosciences
Lab location: Bordeaux
Lab website:https://www.lp2n.institutoptique.fr/

Contact point for this topic: Institut d'Optique Graduate School

Advisor 1: LOUNIS Brahim brahim.lounis@u-bordeaux.fr
Advisor 2: TAMARAT Philippe philippe.tamarat@u-bordeaux.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Lead halide perovskites exhibit outstanding optical and electronic properties for a wide range of applications in optoelectronics and for light-emitting devices. Yet, the physics of the band-edge exciton, whose recombination is at the origin of the photoluminescence, is the subject of ongoing debate. In particular, the long-lived ground exciton of lead halide perovskite nanocrystals plays a major role in the quantum properties of the emitted light, since it promotes the formation of biexcitons and thus the emission of correlated photon pairs. Future investigations will aim at reducing the dephasing rate and spectral diffusion in these materials and improve the indistinguishability character of the emitted photons. With a view to the realization of ideal sources of entangled photons, we will aim at achieving degenerate bright triplet emission. We will also study the quantum optical properties of the photoluminescence stemming from lead halide NCs that are self-organized into highly ordered three-dimensional superlattices. We will investigate the spectroscopic and temporal signatures of collective coupling of the nanocrystals, which should give rise to the many-body quantum phenomenon of superfluorescence. Such entangled multi-photon quantum light sources should fuel the

development of next-generation devices for quantum technologies. These activities will be led in close collaboration with the group of chemists of M. Kovalenko (ETH Zürich).

Required background of the student: Nanophysics, condensed matter, quantum optics

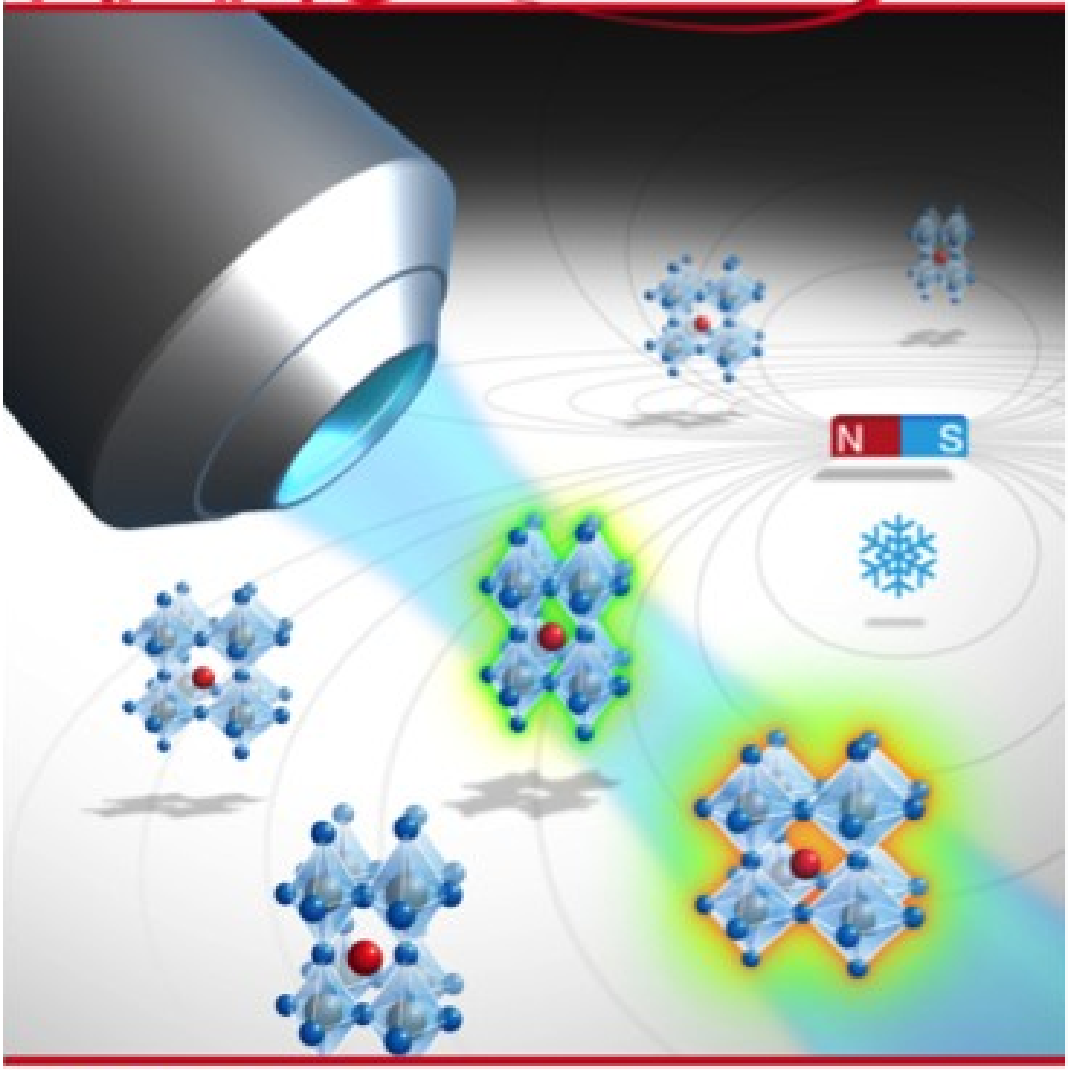
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. “Unraveling the Emission Pathways in Copper Indium Sulfide Quantum Dots”
Chenghui Xia, Philippe Tamarat, Lei Hou, Serena Busatto, Johannes D. Meeldijk, Celso de Mello Donega, and Brahim Lounis, ACS Nano (2021) 15, 17573-17581
2. « The dark exciton ground state promotes photon-pair emission in individual perovskite nanocrystals »
P. Tamarat, L. Hou, J.-B. Trebbia, A. Swarnkar, L. Biadala, Y. Louyer, M. I. Bodnarchuk, M. V. Kovalenko, J. Even, B. Lounis, Nature Communications 11 (2020) 6001.
3. « The ground exciton state of formamidinium lead bromide perovskite nanocrystals is a singlet dark state »,
P. Tamarat et al. Nature Materials, 18 (2019) 717.
4. “Unravelling exciton-phonon coupling in individual FAPbI3 nanocrystals emitting near-infrared single photons”, M. Fu et al., Nature Communications, 9, 3318 (2018).
5. « Neutral and charged exciton fine structure in single lead halide perovskite nanocrystals revealed by magneto- optical spectroscopy », M. Fu et al., Nanoletters, 17 (2017) 2895.

Illustrations :

NANO LETTERS

June 2015
Volume 15, Number 6
pubs.acs.org/NanoLett



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ParisTech

TITLE: AUTOMATIC CAPTURE OF VISUAL DATA FOR DIGITAL TWINS OF WORKSITES

Topic number : ***2022_079***

Field : Information and Communication Science and Technology, ,

Subfield:

ParisTech School: Ecole des Ponts ParisTech
Research team:
Research lab: LIGM - Laboratoire d'Informatique Gaspard Monge
Lab location:
Lab website:https://imagine-lab.enpc.fr

Contact point for this topic: Ecole des Ponts ParisTech

Advisor 1: Lepetit Vincent vincent.lepetit@enpc.fr
Advisor 2: Wang Chaohui chaohui.wang@univ-eiffel.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The goal of this PhD thesis is to develop methods for guiding an Unmanned Aerial Vehicle (UAV) to capture visual data in complex and unknown environments, and for automatically labeling this data. It will be part of the Robat project and make use of the Build'in platform at ENPC. The ultimate goal is to significantly speed up the creation and maintenance of Digital Twins with a focus on worksites. Methods for capturing the 3D geometry of a new scene already exist , the goal here is to focus on and capture visual data for each individual object, from a camera mounted on a UAV. The captured data should be suitable for training supervised methods, so that these objects can then be recognized in the future by simple and fast inference. Currently, capturing such data is done manually by researchers and requires strong understanding of the learning algorithms.

We will start by developing our approach on a simulator, whereas we should also extend it on a real UAV. The key idea we propose for the approach is to start with detections obtained by our segmenter that performs well even on new objects. Then, we will build on our previous work to identify which detections are correct and how to move the camera to get the best coverage of each object.

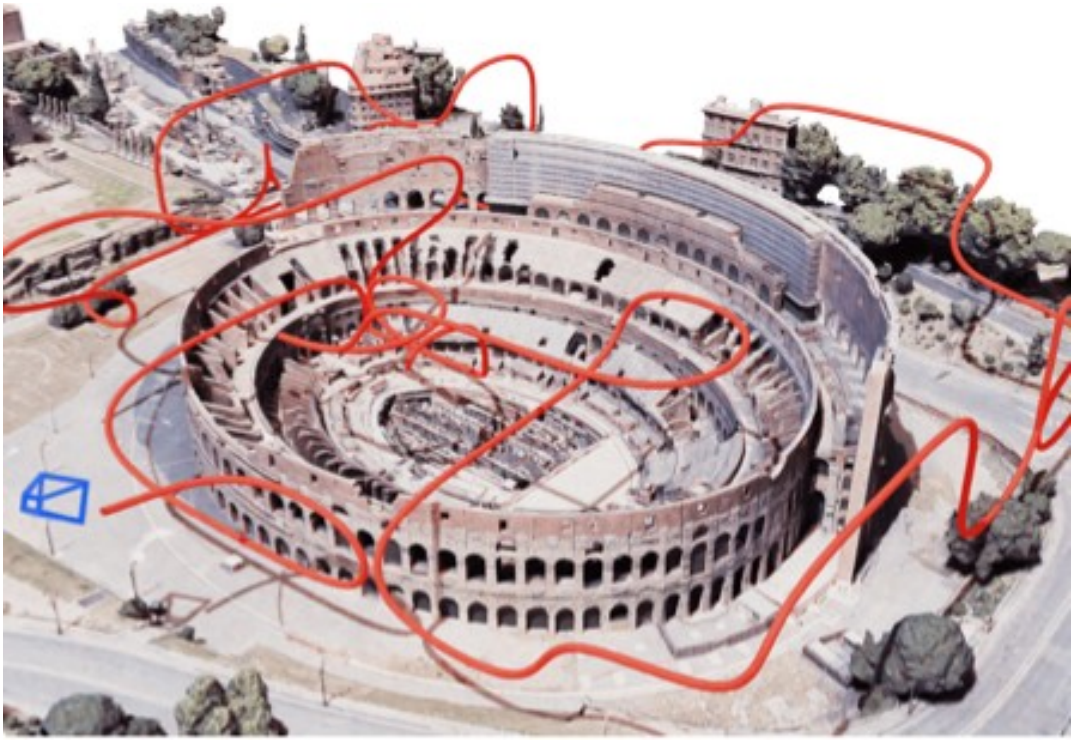
Surface Coverage Optimization in Unknown Environments by Volumetric Integration. Antoine Guédon, Pascal Monasse, Vincent Lepetit. Accepted at NeurIPS 2022.
1st Place Solution for the UVO Challenge on Image-based Open-World Segmentation 2021. Yuming Du, Wen Guo, Yang Xiao, and Vincent Lepetit. ICCV Workshop 2021.
Monte Carlo Scene Search for 3D Scene Understanding. Shreyas Hampali, Sinisa Stekovic, Sayan Deb Sarkar, Chetan Srinivasa Kumar, Friedrich Fraundorfer, and Vincent Lepetit. CVPR 2021.

Required background of the student: Computer Vision, Machine Learning

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. SCONE: Surface Coverage Optimization in Unknown Environments by Volumetric Integration. Antoine Guédon, Pascal Monasse, Vincent Lepetit. Accepted at NeurIPS 2022. https://arxiv.org/abs/2208.10449
2. 1st Place Solution for the UVO Challenge on Image-based Open-World Segmentation 2021. Yuming Du, Wen Guo, Yang Xiao, and Vincent Lepetit. ICCV Workshop 2021. https://arxiv.org/pdf/2110.10239.pdf
3. Monte Carlo Scene Search for 3D Scene Understanding. Shreyas Hampali, Sinisa Stekovic, Sayan Deb Sarkar, Chetan Srinivasa Kumar, Friedrich Fraundorfer, and Vincent Lepetit. CVPR 2021. https://vincentlepetit.github.io/files/papers/comp_hampali_cvpr21.pdf
4.
5.

Illustrations :



ParisTech

INSTITUT d'OPTIQUE GRADUATE SCHOOL ParisTech | université PARIS-SACLAY

TITLE: FAST JOSEPHSON-JUNCTION CONTROL BY OPTICAL MANIPULATION OF A FLUX QUANTUM

Topic number : ***2022_080***

Field : Physics, Optics, ,

Subfield: Condensed matter, superconductivity and magnetism, nanophysics, optics

ParisTech School: Institut d'Optique Graduate School
Research team: Nanophotonics https://bordeaux-nanophotonics.fr/news-and-events/
Research lab: LP2N - Laboratoire Photonique, numérique et nanosciences
Lab location: Bordeaux
Lab website:https://www.lp2n.institutoptique.fr/

Contact point for this topic: Institut d'Optique Graduate School

Advisor 1: LOUNIS Brahim brahim.lounis@u-bordeaux.fr
Advisor 2: TAMARAT Philippe philippe.tamarat@u-bordeaux.fr
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: The miniaturization of semiconductor-based electronic components could reach its limits within a decade. Superconducting electronics, based on quantum flux superconducting logic circuits (Josephson junctions), is a promising alternative offering both high operating rates and low switching energies. Full optical control of Josephson junctions would enable low-power, wideband communication between logic circuits at cryogenic temperatures and room-temperature mass memories. In this context, the thesis objective is the fundamental exploration of the interplay between optics, magnetism and superconductivity, an emerging research field. Innovative optical methods of individual Abrikosov vortex manipulation recently developed in our group offer promising perspectives such as fast optical Josephson junction control by moving a quantum of flux near a junction by photo-thermal effect.
We will also aim at creating the Josephson junction itself by photo-thermal effect, by illuminating the section of a superconducting ribbon. The Josephson electrical transport signatures will be studied according to the geometry and power of the laser beam used to locally weaken the

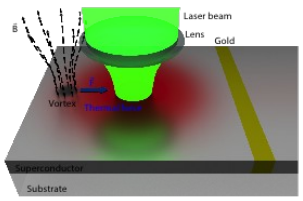
superconductivity. Finally, in the perspective of an all-optical control of superconducting electronic devices, part of the thesis will be dedicated to the creation of flux quanta with a laser pulse, using the inverse Faraday effect.

Required background of the student: Condensed matter, nanophysics, optics

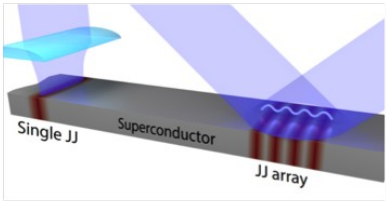
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. "Toward the Light-Operated Superconducting Devices: Circularly Polarized Radiation Manipulates the Current-Carrying States in Superconducting Rings", Croituru et al., Advanced Quantum Technologies, 5 (2022) 2200054
2. “On-Demand Optical Generation of Single Flux Quanta” A. Rochet et al. Nano Letters 20 (2020) 6488.
3. “Anomalous Josephson effect controlled by an Abrikosov vortex”, S. Mironov et al., PRB 96, 214515 (2017)
4. « Optical Manipulation of Single Flux Quanta», I. S. Veschunov et al. Nature Communications 7 (2016) 12801.
5. Patent "Control of the displacement of an individual Abrikosov vortex », A. Bouzdine, B. Lounis, P. Tamarat.

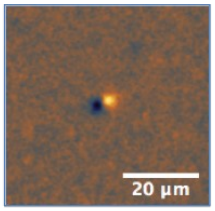
Illustrations :



Control of a Josephson junction with a single vortex.



Sculpting a normal region in a superconductor with light.



Generation of a vortex-antivortex pair with a laser pulse.

ParisTech

ESPCI PARIS PSL

TITLE: VO2-BASED PLASMONIC HYBRID NANOSTRUCTURES FOR TUNABLE OPTICAL SENSORS

Topic number : ***2022_081***

Field : Physics, Optics, Chemistry, Physical chemistry and Chemical Engineering,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: Micro & Nano Characterization group
https://www.espci.psl.eu/recherche/labos/lpem/mnc/index.html
Research lab: LPEM - Laboratoire Physique et d'études des matériaux
Lab location: Paris
Lab website:https://www.lpem.espci.fr/spip.php?rubrique4

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Aigouy Lionel lionel.aigouy@espci.fr
Advisor 2: Zimmers Alexandre alexandre.zimmers@espci.fr
Advisor 3: Chen Zhuoying zhuoying.chen@espci.fr
Advisor 4:

Short description of possible research topics for a PhD: The insulator-metal transition (IMT) in oxides is an intensely investigated phenomenon which has received considerable attention from the basic research community and has the potential to revolutionize applications in electronics, smart optics, energy technologies, data storage... . The material VO2 is extremely interesting because it undergoes a first-order thermally induced IMT above room temperature at Tc= 68°C in which the resistivity changes by several orders of magnitude and is accompanied by strong variations of the refractive index. This unique optical property can be used by depositing nanostructures such as disks or rods on VO2 thin films. These hybrid structures change transmittance, color, and scattering (which vary as a function of geometrical parameters) as temperature is swept across the IMT.
To study and manipulate these hybrid nanostructures, we have recently fabricated at the LPEM-PSL laboratory epitaxial VO2 thin films and nanojunctions above them (fig a, all white scale bars are 10µm long). We also have fabricated plasmonic nanostructures (fig b) that have been used in devices and sensors (photothermal detectors, diffractive elements …). The goal of this thesis research will be to combine these two expertise to:

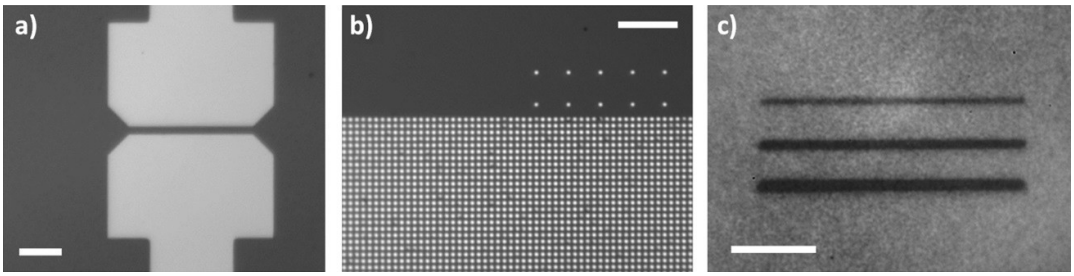
- First, fabricate and characterize VO2 thin films and hybrid nanostructures. By changing the temperature, we will be able to tune the dielectric properties of the local environment, inducing modifications of the plasmon resonances .
- Second, fabricate and characterize photodetectors based on VO2 hybrid plasmonic/dielectric nanostructures. Due to the strong dependence of the VO2 thin film resistance with temperature, it will be possible to fabricate sensitive, low cost photodetectors.
- Finally, design possible new nano-optical devices. This will be done by using unique tools recently developed at the LPEM-PSL: (i) writing micrometer metallic phases in insulating regions by laser-induced heating (fig c); (ii) writing nanoscale metallic or insulating phases (memory domains) by scanning probe microscopies (AFM, EFM) .

Required background of the student: Expected applicant profile: the PhD candidate must have a solid academic background in physics and chemistry and express strong interest in scientific experiments and analysis.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Oxide Electronics Utilizing Ultrafast Metal-Insulator Transition, Z. Yang, C. Ko, and S. Ramanathan, Annu. Rev. Mater. Res. 41, 337–67 (2011)
2. Direct imaging of fluorescence enhancement in the gap between two gold nanodisks. H.-J. Lin et. al., Applied Physics Letters, 118, 161105 (2021)
3. Dynamic Plasmonic Color Generation Based on Phase Transition of Vanadium Dioxide F.-Z. Shu et. al. Adv. Optical Mater., 6, 1700939, (2018)
4. Electric-field-driven phase transition in VO2, Zimmers, et. al. Phys. Rev. B, 84, 241410(R) (2011)
5.

Illustrations :


a)
b)
c)

ParisTech

MINES PARIS | PSL

TITLE: WEARABLE SENSING AND MOVEMENT ANALYTICS FOR THE MONITORING OF OPERATORS/EXPERTS IN INDUSTRY AND CRAFTS

Topic number : ***2022_082***

Field : Mathematics and their applications, Information and Communication Science and Technology, Economics, Management and Social Sciences

Subfield:

ParisTech School: Mines Paris - PSL
Research team:
Research lab: CAOR - Centre de Robotique
Lab location: Paris
Lab website:https://caor-mines-paristech.fr/en/home/

Contact point for this topic: Mines Paris - PSL

Advisor 1: Glushkova Alina alina.glushkova@minesparis.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: the Center for Robotics is looking for a PhD candidate on Wearable sensing and movement analytics for the monitoring of operators /experts in industry and crafts, in order to continue the works . During everyday tasks, operators carry loads and execute ergonomically difficult and dangerous gestures that might cause injuries, such as Musculo-Skeletal Disorders (MSD). MSD is one of the main reasons for occupational diseases that have a direct impact on both the health of the worker and the productivity of the factory. Moreover, both operators and employers tend to be result-oriented, thus ignoring that a less experienced employee is exposed on high risks of temporary injuries, and in the worst case, to temporary or permanent disabilities. The prevention of such injuries becomes thus crucial. From an ergonomical point of view, the monitoring of the gestural performance of the operator can contribute to the prevention of potential injuries that are related to their postures, force application, etc. Through the monitoring of the regular performance of the workers, meaningful information related to their motion behavior can be extracted and modelled based on machine learning. After the motion data acquisition, the student will propose a methodology for an analysis

of these data based on pattern recognition methods. Wearable sensing, such as electromyography for muscle sensing and force sensing, will be used for measuring muscles activation and force application when a task is performed. Furthermore, quantitative evaluation of the muscular load that is associated to risks of MSDs will be done. Correlations between ergonomic peaks with important muscular load and motion parameters such as the motor task, time pressure, level of risk, emotional state and demographics will be explored. The student will deliver a prototype movement analytics platform that provides functionalities to ergonomists and production directors for understanding the motion performance of the workers and detecting dangerous postures that might be related to risks for injuries. Such analysis and monitoring aim at the ergonomics improvement and injury prevention in the workplace through quantitative assessment of occupational exposure in normal work activities.

Required background of the student: Electrical, Mechanical or Computer Engineer, Degree in Applied Mathematics or Msc in Human Factors and Ergonomics or similar with the above degrees. More precisely, the student should have skills on:

• Machine Learning

• Signal processing

• Statistical analysis

• Programming : Matlab, Python, Php, C++, etc..

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Olivas-Padilla, Brenda Elizabeth, et al. "Stochastic-biomechanic modeling and recognition of human movement primitives, in industry, using wearables." Sensors 21.7 (2021): 2497.
2. Olivas-Padilla, Brenda Elizabeth, et al. "Computational ergonomics for task delegation in Human-Robot Collaboration: spatiotemporal adaptation of the robot to the human through contactless gesture recognition." arXiv preprint arXiv:2203.11007 (2022).
3. Stefana, Elena, et al. "Wearable devices for ergonomics: A systematic literature review." Sensors 21.3 (2021): 777.
4.
5.

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: INTEGRATED HUMAN-MACHINE INTERFACE FOR AUTOMATION OF A FLEXIBLE AND AGILE GRINDING PROCESS OF FORGED WORKPIECES WITH INDUSTRIAL ROBOTS

Topic number : ***2022_083***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: LCFC https://lcfc.ensam.eu/lcfc-accueil-119817.kjsp
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:https://lcfc.ensam.eu/lcfc-accueil-119817.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: BIGOT Régis regis.bigot@ensam.eu
Advisor 2: BAUDOUIN Cyrille cyrille.baudouin@ensam.eu
Advisor 3: CHEVRET Sandra sandra.chevret@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: Grinding is necessary to remove overage parts from forged workpieces (flash, surface imperfections, oxide incrustation, etc.). Finishing processes of large forged workpieces are still done manually in most cases. Automation of the finishing process is expected to eliminate the hard manual operations that can lead to musculoskeletal disorders and productivity decrease. Greater accuracy and repeatability of operations is expected. However, at the end of a forging operation, each part is unique, and is the image of the accumulation of all process variabilities.
The artificial intelligence would be able to control the robot to perform grinding according to observations made on the workpiece by human. So, this PhD consists in creating and deploying a methodology that would allow an effective collaboration between the observation of a workpiece, the interpretation made by an operator and the realization of the expected operations by a robot in a context of industrial productivity. The Ph.D. student will develop the background grinding knowledge (artificial neural network, surrogate model, etc.) required to get from, workpiece real geometry to the grinding strategy (trajectory and processing parameters).

Required background of the student: Knowledge in robotics; CAD Design; manufacturing (grinding) if possible; computing; applied mechanics;

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Zimmer, S., Langlois, L., Laye, J., & Bigot, R. (2010). Experimental investigation of the influence of the FSW plunge processing parameters on the maximum generated force and torque. The International Journal of Advanced Manufacturing Technology, 47(1), 201-215.
2. Chaoui, M. D., Léonard, F., & Abba, G. (2019). Improving surface roughness in robotic grinding process. In ROMANSY 22–Robot Design, Dynamics and Control (pp. 363-369). Springer, Cham.
3. Bourlet, C., Zimmer-Chevret, S., Pesci, R., Bigot, R., Robineau, A., & Scandella, F. (2020). Microstructure and mechanical properties of high strength steel deposits obtained by Wire-Arc Additive Manufacturing. Journal of Materials Processing Technology, 285, 116759.
4. Venet, G., Baudouin, C., Pondaven, C., Bigot, R., & Balan, T. (2021). Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations. International Journal of Material Forming, 1-17
5. Wang, Z., Zimmer-Chevret, S., Léonard, F., & Abba, G. (2021). Prediction of bead geometry with consideration of interlayer temperature effect for CMT-based wire-arc additive manufacturing. Welding in the World, 1-12.

Illustrations :

TITLE: ROBUST ROBOTIC GRINDING: PROCESS IDENTIFICATION AND IMPROVEMENT OF THE CONTROL

Topic number : ***2022_084***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: LCFC https://lcfc.ensam.eu/lcfc-accueil-119817.kjsp
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:https://lcfc.ensam.eu/lcfc-accueil-119817.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: BIGOT Régis regis.bigot@ensam.eu
Advisor 2: Raharijaona Thibaut thibaut.raharijaona@univ-lorraine.fr
Advisor 3: CHEVRET Sandra sandra.chevret@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The robotization of the grinding allows to reduce musculoskeletal disorders (MSD), to reduce operator injuries and allows mass production grinding and ensures repeatability of quality. The objective is to develop a robotic grinding control system able of grinding parts while controlling the grinding force, the number of passes to obtaining the required surface finish.
The work will have to allow the grinding of complex geometries with different wheel diameters and to take into account the geometrical variations of the grinding wheel during the operation. This is due to the fact that the wear of the grinding wheel affects its diameter and consequently the rate of material removal and the position of the Tool Center Point (TCP- which is generally defined at the end of the wheel). The goal of this research proposal is to develop a control system dedicated to the automation of robotic grinding. A part of the work will consist in studying and modeling the tool-material interactions by taking into account the wear of the grinding wheel. A model will be established to predict the following operating parameters. This model will be integrated into the control system developed. The whole could also be implemented in a digital twin. The develop model and control command will be simulated and implemented on an industrial grinding robot. The

systems developed in this work will be experimentally applied on real parts in order to validate the whole approach.

Required background of the student: Knowledge in robotics; Control and command system; manufacturing (grinding) if possible; computing; applied mechanics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Wang, Z., Zimmer-Chevret, S., Léonard, F., & Abba, G. (2022). Control of bead geometry using multiple model approach in wire-arc additive manufacturing (WAAM). The International Journal of Advanced Manufacturing Technology, 122(7), 2939-2951.
2. Wang, Z., Zimmer-Chevret, S., Léonard, F., & Abba, G. (2021). Prediction of bead geometry with consideration of interlayer temperature effect for CMT-based wire-arc additive manufacturing. Welding in the World, 65(12), 2255-2266.
3. Venet, G., Baudouin, C., Pondaven, C., Bigot, R., & Balan, T. (2021). Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations. International Journal of Material Forming, 1-17
4. Chaoui, M. D., Léonard, F., & Abba, G. (2019). Improving surface roughness in robotic grinding process. In ROMANSY 22–Robot Design, Dynamics and Control (pp. 363-369). Springer, Cham
5. Wilfrido, P. Q. C., Gabriel, A., Jean-Francois, A., Thibaut, R., & Philippe, G. (2021). Load-dependent Friction Laws of Three Models of Harmonic Drive Gearboxes Identified by Using a Force Transfer Diagram. 12th International Conference on Mechanical and Aerospace Engineering (ICMAE) (pp. 239-244). IEEE.

Illustrations :

ParisTech

Arts et Métiers

TITLE: FINITE ELEMENTS ANALYSIS FOR OPTIMUM PEELING CONDITIONS AND HIGHER VENEER QUALITY: CASE OF THE ROTARY PEELING PROCESS OF EUROPEAN WOOD SPECIES

Topic number : ***2022_085***

Field : Material science, Mechanics and Fluids, Design, Industrialization, Life Science and Engineering for Agriculture, Food and the Environment

Subfield: wodd sciences

ParisTech School: Arts et Métiers
Research team: Wood sciences, Wood peeling, wood grading http://labomap.ensam.eu/wood-material-and-machining-100680.kjsp?RH=1415278881726&RF=1415535985117
Research lab: LABOMAP - Laboratoire Bourguignon des matériaux et procédés
Lab location: Cluny
Lab website:http://labomap.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: Denaud Louis louis.denaud@ensam.eu
Advisor 2: Yaich Mariem mariem.yaich@ensam.eu
Advisor 3: Girardon Stéphane stephane.girardon@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The wood material presents an attractive alternative to reduce the carbon footprint of industry, transport and construction. However, its usage, especially local resource coming from temperate area, is still limited to few applications because of its natural high variability and heterogeneity, which are mostly by seasonal variations. In order to encourage the use of local and fast-growing wood species, the peeling process has been used for many decades for the construction of technical wood products (plywood, LVL, ...) with more homogeneous material properties . The principle of this first transformation process is to produce a continuous ribbon of wood veneer (Figure 1). Contrary to other manufacturing processes, an efficient peeling is defined by its ability to ensure high chip quality, which is the veneer in our case (Figure 2-a), with uniform thickness and less checks propagation (Figure 2-b), while reducing the quantity of nonuniform veneer quality and optimizing the yield. This is still difficult to ensure due to either an inadequate definition of the

machining conditions or an under comprehension of the material behavior. Despite the continuous efforts to experimentally determine the main reasons of the damage initiation and propagation during the material machining , the setting up of a reliable numerical modeling is required to limit experimental tests and to predict veneer properties.
The main purpose of this PhD thesis is to set up a reliable numerical analysis of the peeling process, based on the models recently developed in the LaBoMaP (Figure 3). The high heterogenety of the material will be considered. This study also focuses on identifying the root causes of the check's propagation and the thickness variation within the veneers, while considering the effects of both wood material (anisotropy of the material, its mechanical properties, earlywood / late wood, knots…) and peeling process (cutting speed, compression rate, knife geometry, pressure bar position, initial log temperature…). For more accurate description of the material behavior under severe loading conditions, experimental tests at high strain rates will be set up using the micro-peeling machine of the LaBoMaP. It focuses on identifying, in all principal loading directions, the materials constants of a complex material model, which will be proposed. This model covered the elastic, plastic and damage anisotropy of the investigated material. The non-symmetric failure during the wood tension and compression loadings will be considered to properly predict the chip formation, as well as the initiation and the propagation of the veneer checks. For more realistic simulations of the peeling process, contact conditions in the tool-veneer-pressure bare interfaces will be also investigated to determine the effects of both hydrothermal wood preparation and cutting conditions. This study will be done in the scale of wood growth rings. Material properties of both latewood and earlywood will be considered. The validation of the proposed numerical model will be done based on the experimental results of the wood peeling obtained with the instrumented industrial peeling line of the LaBoMaP (Figure 1-a).
The results of this study will provide support for the industry of the wood peeling, since it explains the phenomena encountered during the wood cutting, proposes alternatives to control the veneer checks propagation and determines the optimal peeling conditions for the investigated wood species.

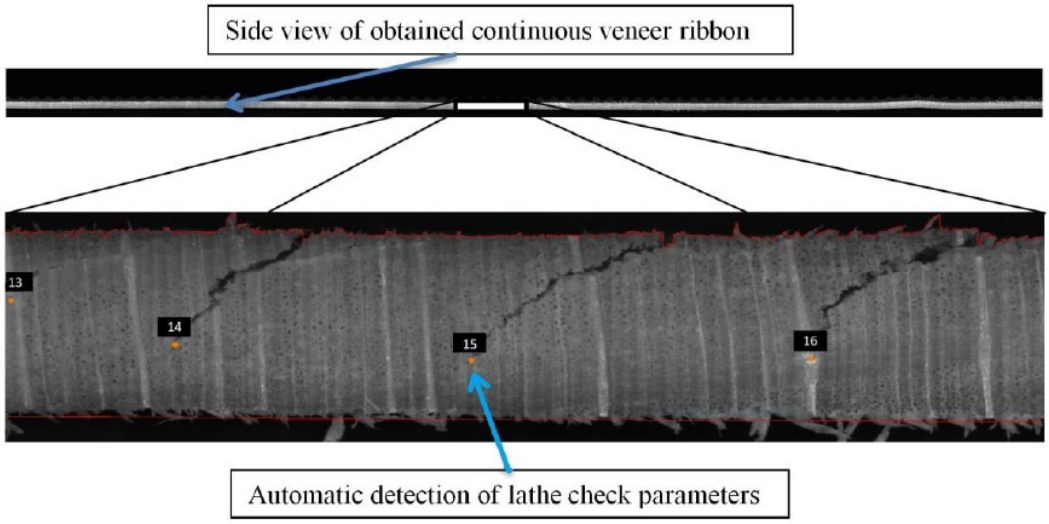
Required background of the student: Mechanical engineering, Finite element analysis (Abaqus), Programming skills (Fortran or Python), Material behavior (A good knowledge of the wood material and its manufacturing will be appreciated)

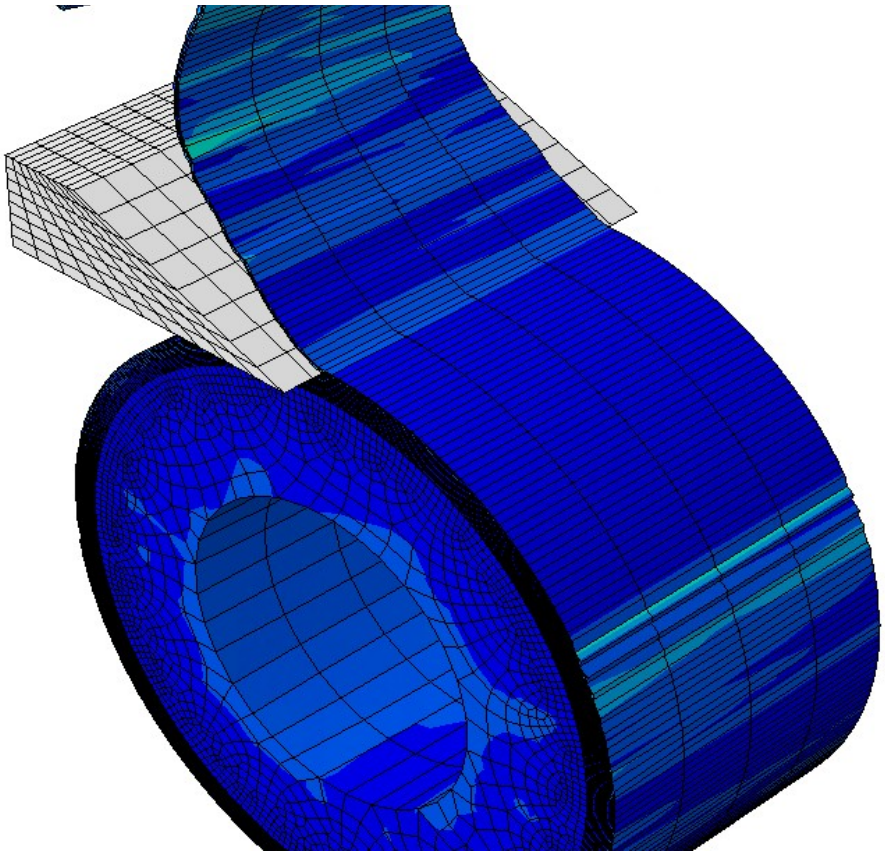
A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. R. Duriot, G. Pot, S. Girardon, B. Roux, B. Marcon, J. Viguier, L. Denaud (2022) New perspectives for LVL manufacturing from wood of

heterogeneous quality – Part 1: Veneer mechanical grading based on online local wood fiber orientation measurement. Forests, 12 (9): 1264
2. Thibaut, B., Denaud, L., Collet, R., Marchal, R., Beauchêne, J., Mothe, F., Méausoone, P.-J., Martin, P., Larricq, P., and Eyma, F. (2016). Wood machining with a focus on French research in the last 50 years. Annals of Forest Science 73, 163–184
3. A. Rohumaa,, J. Viguier, S. Girardon, M Krebs, L. Denaud (2018). Lathe check development and properties: effect of log soaking temperature, compression rate, cutting radius and cutting speed during peeling process of European beech (Fagus sylvatica L.) veneer. European Journal of Wood and Wood products 76 (6), 1653-1661
4. R. Curti (2018). Analyse, modélisation et simulation de la coupe orthogonale du bois vert en vue de son application au fraisage par canter. PhD Thesis
5. Thibaut, B., and Beauchêne, J. (2004). Links between Wood Machining Phenomena and Wood Mechanical Properties: The Case of 0°/90° Orthogonal Cutting of Green Wood.

Illustrations :


Side view of obtained continuous veneer ribbon
13
14
15
16
Automatic detection of lathe check parameters



Research Topic for the ParisTech/CSC PhD Program

Arts et Métiers, Sciences et Technologies

Subfields: Finite Element Modeling, Wood Behavior, Peeling Process, Veneer

Title: Finite elements analysis for optimum peeling conditions and higher veneer quality: Case of the rotary peeling process of European wood species

Advisor(s):

Supervising Professor: Louis DENAUD (Associate Professor Habilited), louis.denaud@ensam.eu, Arts et Métiers Sciences et technologies, LaBoMaP (http://labomap.ensam.eu/)

Thesis advisors : Dr. Mariem YAICH, mariem.yaich@ensam.eu and Dr Stephane GIRARDON stephane.girardon@ensam.eu, Arts et Métiers Sciences et technologies, LaBoMaP (http://labomap.ensam.eu/)

Short description of the main research topics for the PhD student:

The wood material presents an attractive alternative to reduce the carbon footprint of industry, transport and construction. However, its usage, especially local resource coming from temperate area, is still limited to few applications because of its natural high variability and heterogeneity, which are mostly by seasonal variations. In order to encourage the use of local and fast-growing wood species, the peeling process has been used for many decades for the construction of technical wood products (plywood, LVL, …) due to its higher homogeneous material properties [1]. The principle of this first transformation process is to produce a continuous ribbon of wood veneer (Figure 1). Contrary to other manufacturing processes, an efficient peeling is defined by its ability to ensure high chip quality, which is the veneer in our case (Figure 2-a), with uniform thickness and less checks propagation (Figure 2-b), while reducing the quantity of nonuniform veneer quality and optimizing the yield. This is still difficult to ensure due to either an inadequate definition of the machining conditions or an under comprehension of the material behavior. Despite the continuous efforts to experimentally determine the main reasons of the damage initiation and propagation during the material machining [2-4], the setting up of a reliable numerical modeling is required to limit experimental tests and to predict veneer properties.

The main purpose of this PhD thesis is to set up a reliable numerical analysis of the peeling process, based on the models recently developed in the LaBoMaP (Figure 3). The high heterogenety of the material will be considered. This study also focuses on identifying the root causes of the check's propagation and the thickness variation within the veneers, while considering the effects of both wood material (anisotropy of the material, its mechanical properties, earlywood / late wood, knots…) and peeling process (cutting speed, compression rate, knife geometry, pressure bar position, initial log temperature…). For more accurate description of the material behavior under severe loading conditions, experimental tests at high strain rates will be set up using the micro-peeling machine of the LaBoMaP. It focuses on identifying, in all principal loading directions, the materials constants of a complex material model, which will be proposed. This model will cover the elastic, plastic and damage anisotropy of the investigated material. The non-symmetric failure during the wood tension and compression loadings will be considered to properly predict the chip formation, as well as the initiation and the propagation of the veneer checks. For more realistic simulations of the peeling process, contact conditions in the tool-veneer-pressure bare interfaces will be also investigated to determine the effects of both hydrothermal wood preparation and cutting conditions. This study will be done in the scale of wood growth rings. Material properties of both latewood and earlywood will be considered. The validation of the proposed numerical model will be done based on the experimental results of the wood peeling obtained with the instrumented industrial peeling line of the LaBoMaP (Figure 1-a).

The results of this study will provide support for the industry of the wood peeling, since it explains the phenomena encountered during the wood cutting. It proposes alternatives to control the veneer checks propagation and determines the optimal peeling conditions for the investigated wood species.

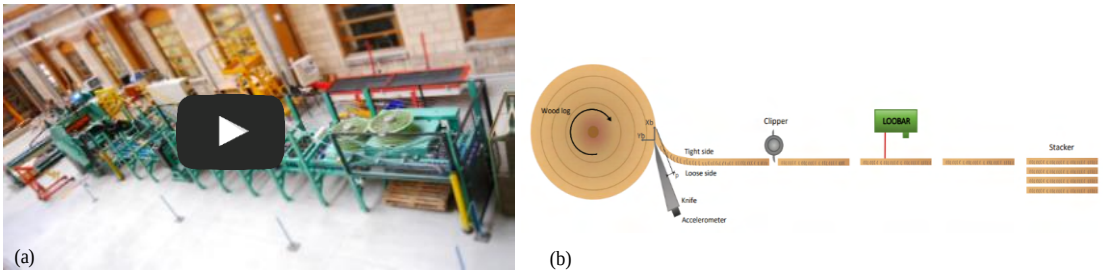


Figure 1 : LaBoMaP's instrumented rotary peeling line: (a) picture of the real line and (b) its schematic representation [1]

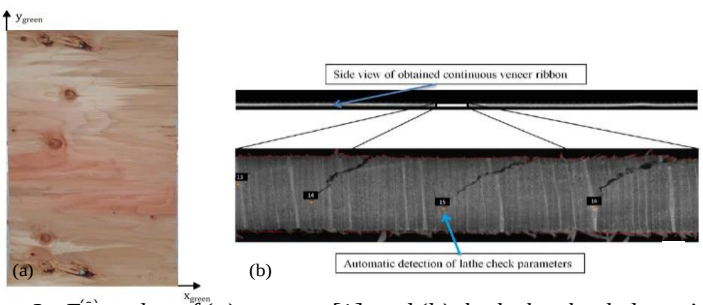


Figure 2 : Examples of (a) veneers [1] and (b) the lathe check detection [5]

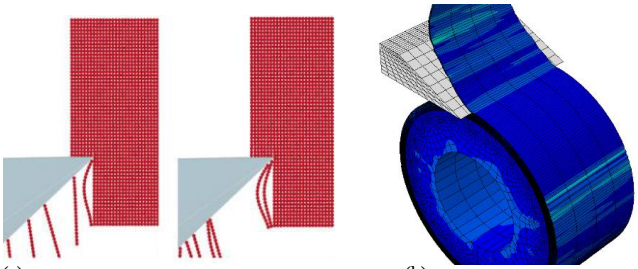


Figure 3 Examples numerical models of the peeling process: (a) DEM [6] and (b) FEM

Required background of the student:

Mechanical engineering, Finite element analysis (Abaqus), Programming skills (Fortran or Python), Material behavior (A good knowledge of the wood material and its manufacturing will be appreciated)

Representative publications of the group: (Related to the research topic)

- [1] R. Duriot, G. Pot, S. Girardon, B. Roux, B. Marcon, J. Viguier, L. Denaud (2022) New perspectives for LVL manufacturing from wood of heterogeneous quality – Part 1: Veneer mechanical grading based on online local wood fiber orientation measurement. *Forests*, 12 (9): 1264
- [2] Thibaut, B., and Beauchêne, J. (2004). Links between Wood Machining Phenomena and Wood Mechanical Properties: The Case of 0°/90° Orthogonal Cutting of Green Wood.
- [3] S. Stefanowski, R. Frayssinhes, G. Pinkowski, L. Denaud (2020). Study on the in-process measurements of the surface roughness of Douglas fir green veneers with the use of laser profilometer. European Journal of Wood and Wood Products, 78 (3), 555-564
- [4] Thibaut, B., Denaud, L., Collet, R., Marchal, R., Beauchêne, J., Mothe, F., Méausoone, P.-J., Martin, P., Larricq, P., and Eyma, F. (2016). Wood machining with a focus on French research in the last 50 years. Annals of Forest Science *73*, 163–184
- [5] A. Rohumaa,, J. Viguier, S. Girardon, M Krebs, L. Denaud (2018). Lathe check development and properties: effect of log soaking temperature, compression rate, cutting radius and cutting speed during peeling process of European beech (Fagus sylvatica L.) veneer. European Journal of Wood and Wood products 76 (6), 1653-1661
- [6] R. Curti (2018). Analyse, modélisation et simulation de la coupe orthogonale du bois vert en vue de son application au fraisage par canter. PhD Thesis

TITLE: SEISMIC CYCLE CHARACTERISTICS AND DEPENDENCE ON ROCK RHEOLOGY AND FRICTION

Topic number : ***2022_086***

Field : Material science, Mechanics and Fluids, Environment Science and Technology, Sustainable Development, Geosciences, Physics, Optics

Subfield:

ParisTech School: Arts et Métiers
Research team: DIPPE https://lampa.ensam.eu/equipe-dippe-axe-sec-144046.kjsp?RH=1478611690252
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:https://lampa.ensam.eu/accueil-lampa-100748.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: AMMAR Amine amine.ammar@ensam.eu
Advisor 2: EL AREM saber saber.elarem@ensam.eu
Advisor 3: Latour Soumaya soumaya.latour@irap.omp.eu
Advisor 4:

Short description of possible research topics for a PhD:
Understanding how earthquakes initiate on active faults and whether this initiation could be detected is an issue of foremost importance in seismology. However, because the
physical process of co-seismic rupture corresponds to the development of an instability, its physics is highly non-linear, and involves many scale-dependent processes. This leads
to fundamental challenges in studying rupture initiation and propagation whether it be theoretically, numerically or experimentally.
An experimental setup has allowed interesting observations of rupture nucleation, in this study we aim to reproduce numerically the experimental results. Nucleation on a heterogeneous interface with a periodic friction heterogeneity has been considered. It was shown experimentally that a large scale globally accelerating nucleation process can develop on a heterogeneous fault, while the details of the rupture propagation are controlled at smaller scale by the friction heterogeneity.
The numerical model will help in better understanding of the rupture

process by comparing with the experimental results and discussing their relevance with respect to recent theoretical developments and to earthquakes preparatory processes. We want to derive a reliable friction law to be used in numerical exploration of seismic cycle characteristics and dependence on rock rheology and friction.

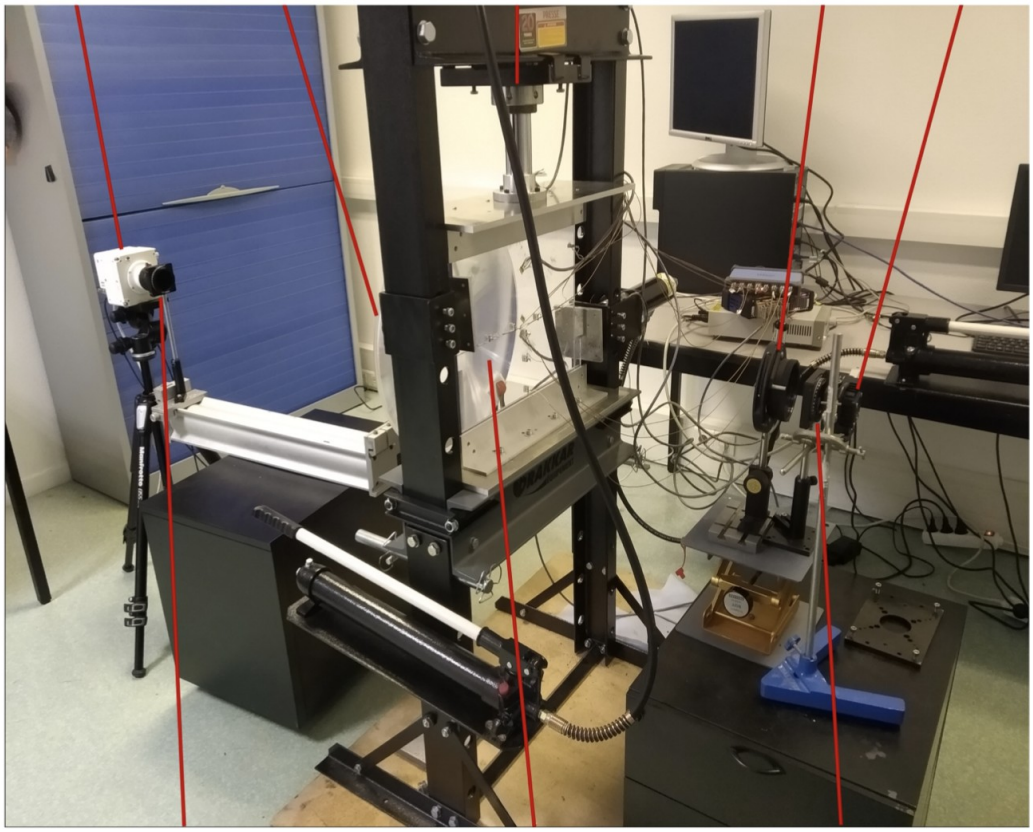
Required background of the student: solid Mechanics, geophysics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

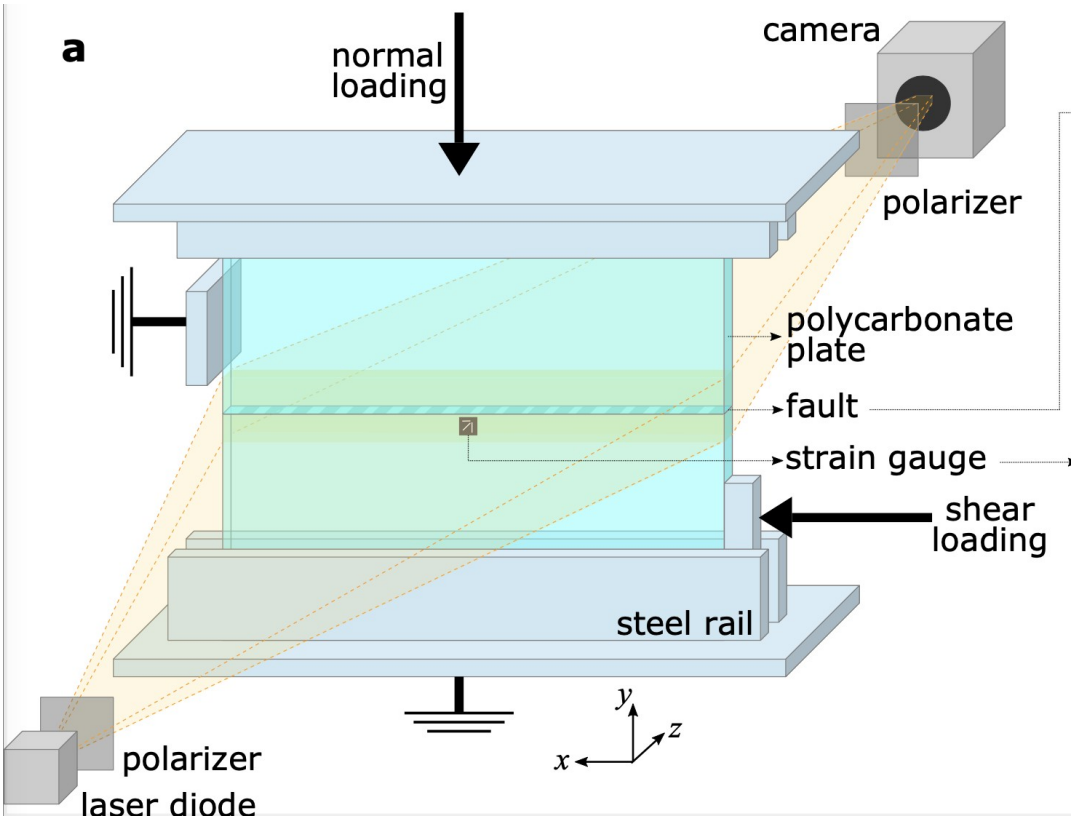
1. Latour, S., Schubnel, A., Nielsen, S., Madariaga, R., & Vinciguerra, S. (2013). Characterization of nucleation during laboratory earthquakes.Geophysical Research Letters,40440(19), 5064–5069.
2. Gounon, A., Latour, S., Letort, J., & El Arem, S. (2022). Rupture nucleation on a periodically heterogeneous interface. Geophysical Research Letters, 49, e2021GL096816. https://doi.org/10.1029/2021GL096816
3. P. Bernard, H. Lyon-Caen, al. Tectonophysics, Volume 426, Issues 1–2, 30 October 2006, Pages 7–30
4. S. El Arem, H. Lyon-Caen, P. Bernard, J-D Garaud, F. Rolandone, and P. Briole. In EGU General Assembly Conference , volume 15, page 14477, Vienna, Austria, 2013
5. Michel, Clotaire and Guéguen, Philippe and El Arem, Saber and Mazars, Jacky and Kotronis, Panagiotis, Full-scale dynamic response of an RC building under weak seismic motions using earthquake recordings, ambient vibrations and modelling, Earthquake Engineering \& Structural Dynamics, 39(4), 419-441, https://doi.org/10.1002/eqe.948

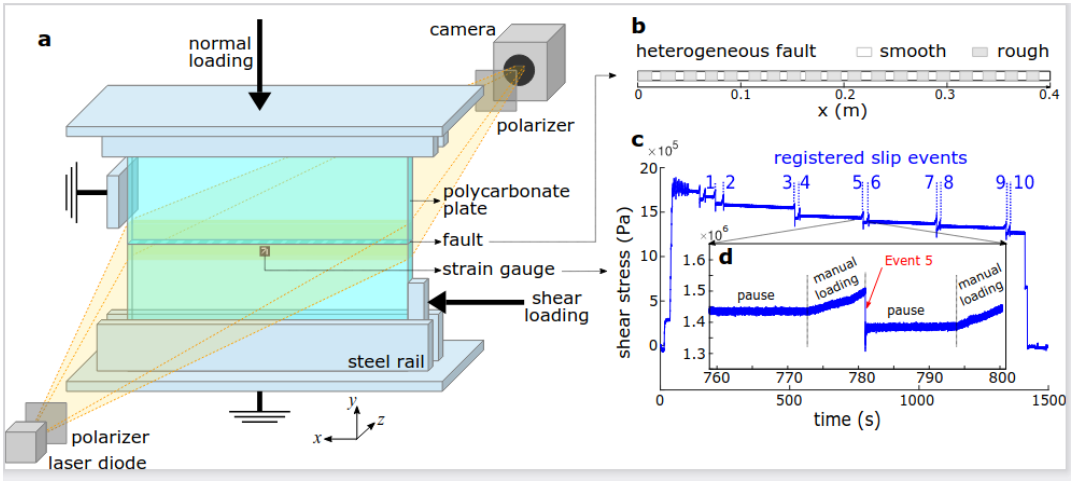
Illustrations :

a) Camera Fresnel lens Bi-axial press Cylindrical lens Laser



Polarizer Polycarbonate plate Polarizer




a
normal loading
camera
polarizer
polycarbonate plate
fault
strain gauge
shear loading
steel rail
polarizer
laser diode
b
heterogeneous fault
smooth
rough
x (m)
c
registered slip events
shear stress (Pa)
time (s)
d
pause
manual loading
Event 5
pause
manual loading

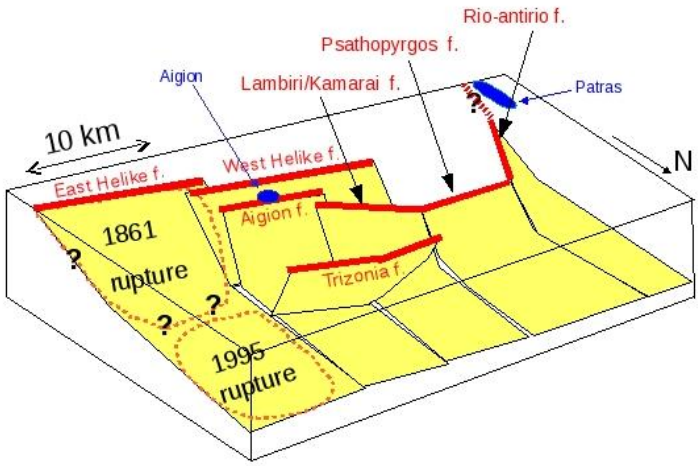


Figure 1: sketch of the major active faults of the CRL area. *Surface scarps in red. Trizonia fault is the only south dipping fault. The 1995 may have occurred on the Helike fault (uncertain dip and connectivity)*

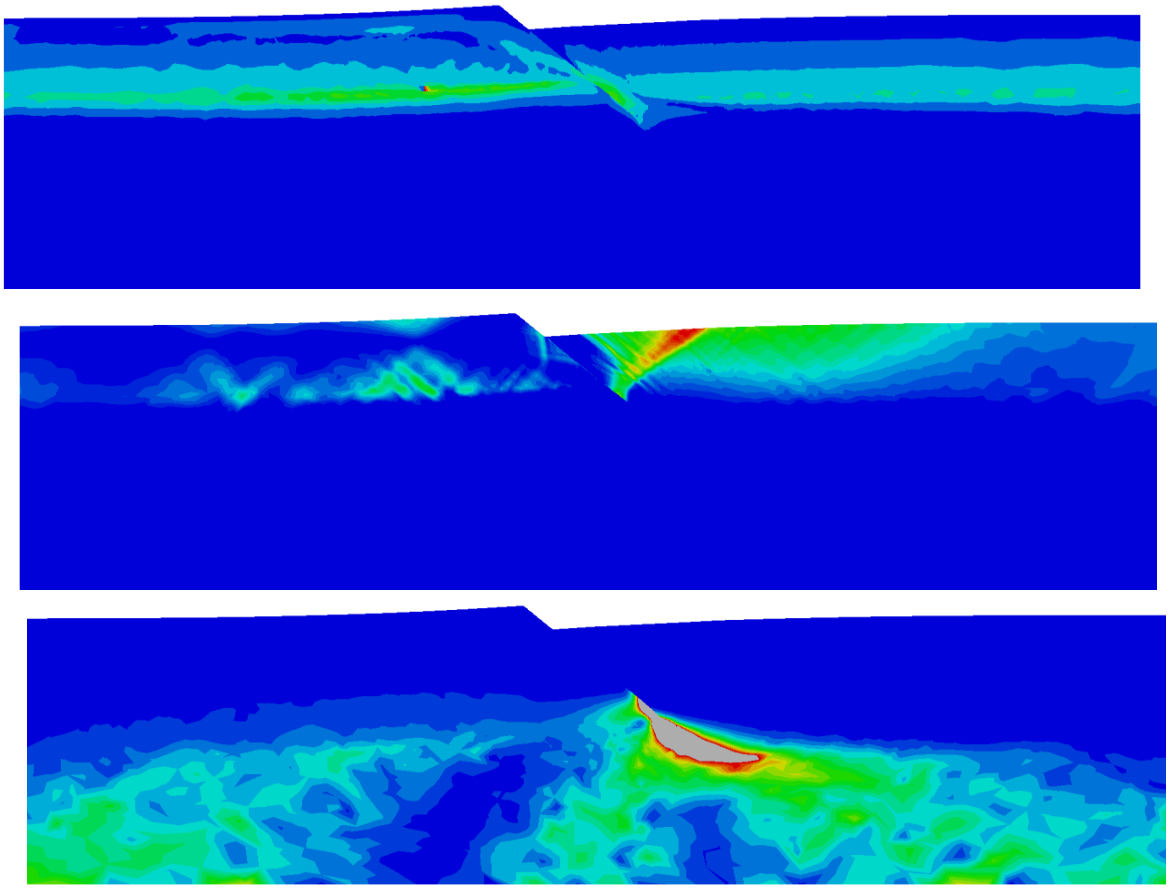


Figure 1: Stress and strain near fault zone. (a)Mises equivalent stress ***(b)*** Equivalent plastic strain ***(c)*** Equivalent creep strain***.***

ParisTech

Arts et Métiers

TITLE: DYNAMIC BEHAVIOR MODELS FOR INDUSTRIAL FORGING PROCESSES

Topic number : ***2022_087***

Field : Design, Industrialization, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:https://lcfc.ensam.eu/lcfc-accueil-119817.kjsp

Contact point for this topic: Arts et Métiers

Advisor 1: Bigot Régis regis.bigot@ensam.eu
Advisor 2: Camille Durand camille.durand@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In the aeronautic sector, the forged parts will soon have to be tracked all along their production to ensure their quality. But production systems like forging hammers are not equipped to monitor process parameters and the instrumentation of such hammer is often not possible. Thus, the dynamic behavior of forging machines has to be modeled. The focus is set on energy restricted machines like hammers and screw presses. The objective of the thesis is to determine a dynamic and predictive model of forging machines and to identify the model parameters through experiments. The model should be valid before, during and after the forging blow. Once the dynamic and predictive model is defined and validated, the goal would be to deduce a reduced model. The thesis aims at pushing the machine modeling forward to reach real-time prediction of machine reactions.

Required background of the student: The candidate should be initiated to mechanical engineering and in mathematics, especially in solid mechanics. Some background in metal forming processes would be helpful, and some curiosity for this application field is needed. A certain experience in programing (Python) is necessary.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. C. Giraud-Audine, T.H. NGuyen, B Lemaire-Semail, G Abba, R Bigot, Modelling of forging processes assisted by piezoelectric actuators : principles and experimental validation, IEEE Transactions on Industry Applications, Vol. 50, n°1, p.244-252, (2014)
2. G Venet, C Baudouin, C Pondaven, R Bigot, T Balan, Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations, International Journal of Material Forming 14 (2021) 929–945
3. Mull, J. F., Durand, C., Baudouin, C., & Bigot, R. (2020). A new tailored solution to predict blow efficiency and energy consumption of hammer-forging machines. The International Journal of Advanced Manufacturing Technology, 111(7), 1941-1954.
4. C Schwarz, P Ackert, R Mauermann, Principal component analysis and singular value decomposition used for a numerical sensitivity analysis of a complex drawn part, Int J Adv Manuf Technol (2018) 94:2255–2265
5.

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: SURROGATE MODELS FOR INDUSTRIAL METAL FORMING PROCESSES OPTIMIZATION

Topic number : ***2022_088***

Field : Design, Industrialization, Material science, Mechanics and Fluids,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://www.lcfc.fr

Contact point for this topic: Arts et Métiers

Advisor 1: Balan Tudor tudor.balan@ensam.eu
Advisor 2: Baudouin Cyrille cyrille.baudouin@ensam.eu
Advisor 3: Homri Lazhar lazhar.homri@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: The development of data-driven surrogate models for complex manufacturing processes is essential to set up a reactive and agile production system, that adapts to production or order hazards in order to ensure an optimal quality and productivity. The project aims to apply machine learning techniques to the field of metal forming processes. The scientific challenges lie in the identification and formulation of the parameters and variables within surrogate models to describe the complexity of the manufacturing processes, particularly their incremental / sequential nature, and to develop almost real-time models, whereas traditional modeling requires hours or even days of calculation for a single process prediction. Typical metal forming processes aimed in the thesis are stamping (of both bulk and sheet metals), open-die forging, incremental forming.

Required background of the student: The candidate should be initiated to data-driven approaches and in particular surrogate model development (polynomial chaos, krigging, neural networks…). Some background in metal forming processes would be helpful, and some curiosity for this application field is needed. A certain experience in programing (Python) is necessary.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. G Venet, T Balan, C Baudouin, R Bigot, Direct usage of the wire drawing process for large strain parameter identification, International Journal of Material Forming 12 (2019) 875–888
2. Zouhri, W., Homri, L. & Dantan, JY. Identification of the key manufacturing parameters impacting the prediction accuracy of support vector machine (SVM) model for quality assessment. Int J Interact Des Manuf 16, 177–196 (2022)
3. W Zouhri, JY Dantan, B Häfner, N Eschner, L Homri, G Lanza, O Theile, Characterization of laser powder bed fusion (L-PBF) process quality: A novel approach based on statistical features extraction and support vector machine, Procedia CIRP 99, 319-324
4. G Venet, C Baudouin, C Pondaven, R Bigot, T Balan, Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations, International Journal of Material Forming 14 (2021) 929–945
5. C Schwarz, P Ackert, R Mauermann, Principal component analysis and singular value decomposition used for a numerical sensitivity analysis of a complex drawn part, Int J Adv Manuf Technol (2018) 94:2255–2265

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: REAL-TIME MODEL DEVELOPMENT FOR INCREMENTAL SHEET METAL FORMING

Topic number : ***2022_089***

Field : Design, Industrialization, Material science, Mechanics and Fluids,

Subfield: Mechanical / Material / Process Engineering

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://www.lcfc.fr

Contact point for this topic: Arts et Métiers

Advisor 1: Balan Tudor tudor.balan@ensam.eu
Advisor 2: Chevret Sandra sandra.chevret@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Incremental sheet metal forming is a recent manufacturing process with excellent potential. The great process freedom induces unprecedented complexity in modeling, in particular when real-time models are aimed for. On the one hand, the development of surrogate models for such an industrial metal forming process is a challenge on its own. On the other hand, the parametric description of large families of manufactured parts within a single surrogate model is a new scientific challenge with respect to the existing literature. Within the project, an experimental database will be generated using the modern robotic incremental forming cell available at the laboratory. Innovative methods of design of experiments (DoE) will be tested and implemented on the experimental platform, along with multi-sensor data acquisition to feed the developed model.

Required background of the student: A certain experience in programing (Python) is necessary. The candidate should be initiated to machine learning and in particular surrogate model development and design of experiments. The candidate should have a first lab experience with experimental research, ideally involving manufacturing processes / machines. Some background in metal forming processes would be helpful, and at least some curiosity for this application field is needed.

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. KOLEGAIN, Komlan, LEONARD, François, CHEVRET, Sandra, et al. Off-line path programming for three-dimensional robotic friction stir welding based on Bézier curves. Industrial Robot: An International Journal, 2018
2. ZIMMER, Sandra, LANGLOIS, Laurent, LAYE, Julien, et al. Experimental investigation of the influence of the FSW plunge processing parameters on the maximum generated force and torque. The International Journal of Advanced Manufacturing Technology, 2010, vol. 47, no 1, p. 201-215
3. VENET, Gabriel, BAUDOUIN, Cyrille, PONDAVEN, Corentin, et al. Parameter identification of 42CrMo4 steel hot forging plastic flow behaviour using industrial upsetting presses and finite element simulations. International Journal of Material Forming, 2021, vol. 14, no 5, p. 929-945
4. ZOUHRI, Wahb, HOMRI, Lazhar, et DANTAN, Jean-Yves. Identification of the key manufacturing parameters impacting the prediction accuracy of support vector machine (SVM) model for quality assessment. International Journal on Interactive Design and Manufacturing (IJIDeM), 2022, vol. 16, no 1, p. 177-196
5. WIEBENGA, J. H., WEISS, M., ROLFE, B., et al. Product defect compensation by robust optimization of a cold roll forming process. Journal of Materials Processing Technology, 2013, vol. 213, no 6, p. 978-986

Illustrations :

ParisTech

ESPCI PARIS PSL

TITLE: VIOLATION OF BELL'S INEQUALITIES IN SOFTMATTER SYSTEMS

Topic number : ***2022_090***

Field : Material science, Mechanics and Fluids, Physics, Optics,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team:
Research lab: GULLIVER - Voyages expérimentaux et théoriques en matière molle
Lab location:
Lab website:https://www.gulliver.espci.fr/?-home-

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Labousse Matthieu matthieu.labousse@espci.fr
Advisor 2:
Advisor 3:
Advisor 4:

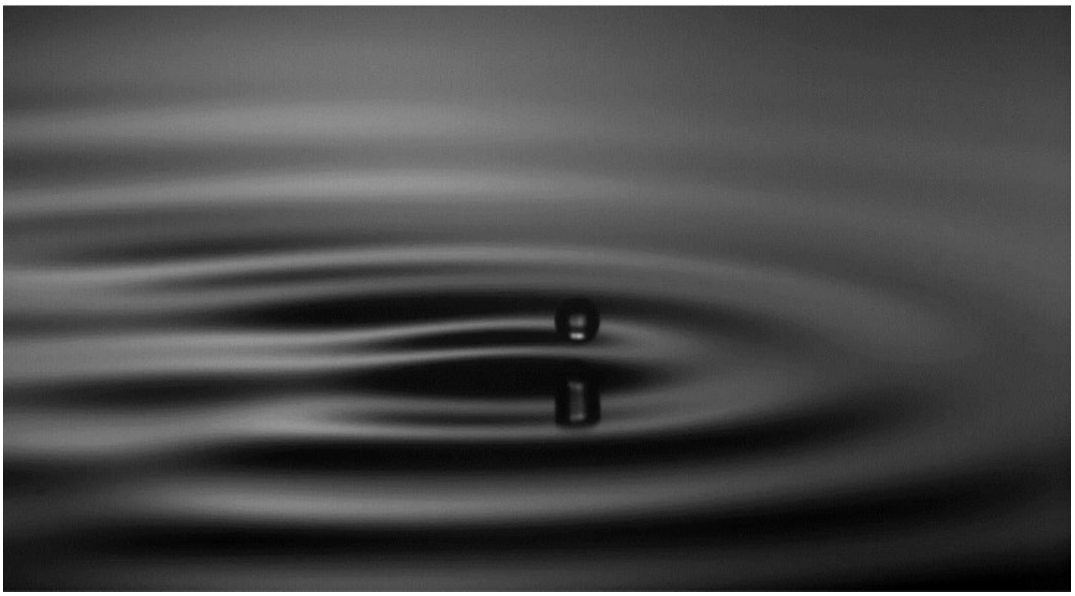
Short description of possible research topics for a PhD: During the last decade, a series of works have shown that wave-particle duality is not restricted to the sole quantum scale (Couder et al. Nature 2005). It is possible to create such a system with a submillimetric drop bouncing on a vertically-vibrated bath. The drop is self-propelled by a standing Faraday waves system while successive impacts renew the wave field. This is an experimental implementation of a wave-pilot system, as imagined by De Broglie, allowing to reproduce effects which were thought to be restricted to the quantum world: diffraction, Young's slit, tunneling, Landau's level analogue, quantized and degenerate states in 2D harmonic potential, statistical superposition of states, etc...We have recently performed numerical simulations and experiments which have shown that a two-droplets system can violate Bell’s inequalities under specific circumstances. This experimentally-oriented PhD will investigate and rationalize this astonishing property which up to now was thought to be restricted to entangled quantum systems, as greatly illustrated by the 2022 Nobel prize.

Required background of the student:

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. https://www.nature.com/articles/s42005-022-00918-y
2. https://arxiv.org/pdf/2208.08940.pdf
3. https://www.nature.com/articles/s41467-022-31736-z
4.
5.

Illustrations :



ParisTech

ESPCI PARIS PSL

TITLE: INVESTIGATING THE ROLE OF LRRK2 IN THE GUT-BRAIN AXIS IN PARKINSON'S DISEASE USING DROSOPHILA

Topic number : ***2022_091***

Field : Life and Health Science and Technology, Life Science and Engineering for Agriculture, Food and the Environment,

Subfield:

ParisTech School: ESPCI Paris - PSL
Research team: Genes Circuits Rhythms and Neuropathology https://www.bio.espci.fr/-Serge-Birman-Genes-Circuits-29-
Research lab: Plasticité du cerveau
Lab location: Paris
Lab website:https://www.bio.espci.fr/-Home-

Contact point for this topic: ESPCI Paris - PSL

Advisor 1: Birman Serge serge.birman@espci.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Parkinson's disease (PD) is the most common neurodegenerative movement disorder in humans, characterized by the dysfunction and loss of a significant proportion of midbrain dopaminergic neurons. The primary causes of the pathology remain poorly understood and there is currently no cure for this disease. An increase in oxidative stress, chronic neuroinflammation and the disruption of cellular degradation processes such as the autophagy-lysosome pathway appear to be major determinants of the pathogenesis. The majority of PD cases are sporadic, while about 10% are linked to mutations in several genes, in particular SNCA that encodes alpha-synuclein and LRRK2, whose autosomal dominant mutations are the most common cause of familial PD in some populations. The gut and the brain influence each other via four bi-directional pathways: endocrine, immunological, metabolic and nervous, the so-called gut-brain axis, the role of which in PD is currently a very active area of research. In our laboratory, we use Drosophila to study the cellular and molecular mechanisms of PD pathogenesis. The aim of this PhD project will be to carry out an in-depth analysis on the role of the LRRK2 protein on cellular

interactions and the gut-brain axis during disease progression in environmental and genetic models of PD in Drosophila.

Required background of the student: Master's degree in Life Sciences or Agriculture, ideally with previous training in molecular biology

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Dulac, A., Issa, A.-R., Sun, J., Matassi, G., Jonas, C., Chérif-Zahar, B., Cattaert, D., Birman, S. (2021) A novel neuron-specific regulator of the V-ATPase in Drosophila. eNeuro 8(5):ENEURO.0193-21.2021. doi:10.1523/ENEURO.0193-21.2021

2. Yon, M., Decoville, M., Sarou-Kanian, V., Fayon, F., Birman, S. (2020) Localized metabolic profiling of living Drosophila in neurodegenerative conditions using 1H magic angle spinning NMR. Sci. Rep. 10(1), 9516–9. doi:10.1038/s41598-020-66218-z

3. Hajji, K., Mteyrek, A., Sun, J., Cassar, M., Mezghani, S., Leprince, J., Vaudry, D., Masmoudi-Kouki, O.*, Birman, S.* (2019) Neuroprotective effects of PACAP against paraquat-induced oxidative stress in the Drosophila central nervous system. Hum. Mol. Genet. 28(11):1905-1918. doi:10.1093/hmg/ddz031 *Co-corresponding authors

4. Issa A.-R., Sun J., Petitgas C., Mesquita A., Dulac A., Robin M., Mollereau B., Jenny A., Chérif-Zahar B., Birman S. (2018) The lysosomal membrane protein LAMP2A promotes autophagic flux and prevents SNCA-induced Parkinson disease-like symptoms in the Drosophila brain. Autophagy 14(11):1898–1910. doi:10.1080/15548627.2018.1491489

5. Sun J., Xu A. Q., Giraud J., Poppinga H., Riemensperger T, Fiala A., Birman S. (2018) Neural control of startle-induced locomotion by the mushroom bodies and associated neurons in Drosophila. Front. Syst. Neurosci. 12:6, doi:10.3389/fnsys.2018.00006/full

Illustrations :

TITLE: HOW TO INTEGRATE ROBOTS TO THE CO-DESIGN OF PRODUCT VARIETY AND ITS RECONFIGURABLE MANUFACTURING SYSTEMS (RMS)

Topic number : ***2022_093***

Field : Design, Industrialization, ,

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: DANTAN Jean-Yves jean-yves.dantan@ensam.eu
Advisor 2: STIEF Paul paul.stief@ensam.eu
Advisor 3: KOESSLER Adrien adrien.koessler@univ-lorraine.fr
Advisor 4:

Short description of possible research topics for a PhD: Today's industrial environment is still marked by an ongoing trend towards more customised products. In addition, the past years have shown an increasing instability of the worldwide economy due to an accumulation of catastrophes and crises. This very fluctuating ecosystem confronts industrial production companies with serious challenges regarding the outset of their production systems. Lot sizes are decreasing and become instable, as well as product demand in general. Therefore, achieving a quick return of invest with single product manufacturing and assembly lines becomes harder.
To achieve this, the thesis objective is to develop a metric to link product variety needs to robot capacities by analysing product structure, operations and robot capacities. Based on this metric a co-design approach should be developed, in order (i) to identify optimum use of robots in the reconfigurable production system, and (ii) to determine specifications of the robotic systems with regards to mechanical characteristics, control algorithms, additional sensor equipment and collaboration ability.
To conclude, there is a lack of research work concerning the integration of robot potential into a co-design approach of product variety and its reconfigurable production system. The research question is how to

consider robot reconfiguration potential in a reconfigurable production system in early design stages throughout a co-development approach (product-production system).

Required background of the student: Mechanical Engineering, Design Methods, Mechanics, Robotics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. A.-L. Andersen, T. D. Brunoe, K. Nielsen, and C. Rösiö, ‘Towards a generic design method for reconfigurable manufacturing systems’, Journal of Manufacturing Systems, vol. 42, pp. 179–195, Jan. 2017, doi: 10.1016/j.jmsy.2016.11.006.
2. Y. Koren and M. Shpitalni, ‘Design of reconfigurable manufacturing systems’, Journal of Manufacturing Systems, vol. 29, no. 4, pp. 130–141, Jan. 2010, doi: 10.1016/j.jmsy.2011.01.001.
3. P. Stief, A. Etienne, J.-Y. Dantan, and A. Siadat, ‘A methodology for production system design driven by product modelling and analysis – application in the automotive industry’, International Journal of Production Research, pp. 1–17, Feb. 2022, doi: 10.1080/00207543.2022.2036382.
4. C. Bouzgarrou, A. Koessler and N. Bouton, "Singularity analysis and reconfiguration mode of the 3-CRS parallel manipulator," 2020 IEEE International Conference on Robotics and Automation (ICRA), 2020, pp. 10384-10390, doi: 10.1109/ICRA40945.2020.9197337.
5.

Illustrations :

Proposal PhD Thesis – CSC

How to integrate robots to the co-design of product variety and its reconfigurable manufacturing systems (RMS)

Context: Today's industrial environment is still marked by an ongoing trend towards more customised products. In addition, the past years have shown an increasing instability of the worldwide economy due to an accumulation of catastrophes and crises. This very fluctuating ecosystem confronts industrial production companies with serious challenges regarding the outset of their production systems. Lot sizes are decreasing and become instable, as well as product demand in general. Therefore, achieving a quick return of invest with single product manufacturing and assembly lines becomes harder.

On the side of product development, modular design approaches, delayed product development and design for assembly/manufacturing have been developed to manage product variety and control its impact on the production system. These approaches are seconded by a large amount of similarity indices and similarity analysis methods. On the side of the production system, the paradigms of agility, reconfigurability and flexibility have been introduced to manage the system adaptability. Advances in robotics of the last decades have increased the potential of achieving reconfigurability. Collaborative robotics (in multi-robot or human-robot settings) and sensor-based control are examples of such advances.

Scientific issue: Design of RMS in general has been addressed in several works [1], [2] as well as product variety management [3], [4]. Also, reconfigurable systems are outset to respond exactly to the adaptability need of a product family [5], [6]. The use of robots is addressed for instance in separated research work [7]–[9]. However, little research has been carried out to combine co-development, RMS and robot capacities for reconfiguration. Figure 1 illustrates different problematics linked to these issues: In classical applications, robots are used for part transfer in linear production lines. This configuration does not use the full reconfiguration potential of robots. A robotised reconfigurable production system using robots in different configurations to realise assembly and manufacturing operations can overcome this shortcoming. Also, breaking a constraint linear workflow can open new possibilities to work flow management.

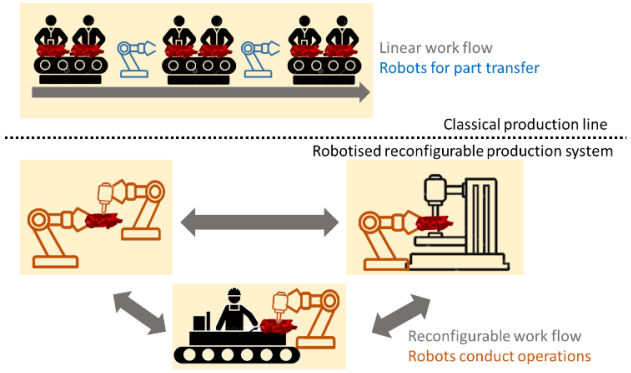


Figure 1. Linear system vs robotised reconfigurable system

To achieve this, the thesis objective is to develop a metric to link product variety needs to robot capacities by analysing product structure, operations and robot capacities. Based on this metric a co-design approach should be developed, in order (i) to identify optimum use of robots in the reconfigurable production system, and (ii) to determine specifications of the robotic systems with regards to mechanical characteristics, control algorithms, additional sensor equipment and collaboration ability.

To conclude, there is a lack of research work concerning the integration of robot potential into a co-design approach of product variety and its reconfigurable production system. The research question is ***how to consider robot reconfiguration potential in a reconfigurable production system in early design stages throughout a co-development approach (product-production system).***

Thesis perimeter (to refine by the candidate):

- Locate the research work in applied robotics and reconfigurability research streams
- Identify work done on the reconfiguration/adaptation capacities of robots in the production system
- Determine the exact scope of the thesis (assembly/ manufacturing/…)
- Identify criteria for the efficient integration of robots into a reconfigurable production system
- Propose tools to model robotic system capability, based on its hardware and software properties
- Develop a design method, considering product and process variety to optimally use the reconfiguration potential of robots (a practical, methodology oriented work is more expected than mathematical modelling and operations research)

[1] A.-L. Andersen, T. D. Brunoe, K. Nielsen, and C. Rösiö, 'Towards a generic design method for reconfigurable manufacturing systems', *Journal of Manufacturing Systems*, vol. 42, pp. 179–195, Jan. 2017, doi: 10.1016/j.jmsy.2016.11.006.
[2] Y. Koren and M. Shpitalni, 'Design of reconfigurable manufacturing systems', *Journal of Manufacturing Systems*, vol. 29, no. 4, pp. 130–141, Jan. 2010, doi: 10.1016/j.jmsy.2011.01.001.
[3] P. Stief, A. Etienne, J.-Y. Dantan, and A. Siadat, 'A methodology for production system design driven by product modelling and analysis – application in the automotive industry', *International Journal of Production Research*, pp. 1–17, Feb. 2022, doi: 10.1080/00207543.2022.2036382.
[4] H. A. ElMaraghy *et al.*, 'Product variety management', *CIRP Annals - Manufacturing Technology*, vol. 62, no. 2, pp. 629–652, Jan. 2013, doi: 10.1016/j.cirp.2013.05.007.
[5] Y. Koren, X. Gu, and Guo W., 'Reconfigurable manufacturing systems: Principles, design, and future trends', *Front. Mech. Eng.*, vol. 13, no. 2, pp. 121–136, Jan. 2018, doi: 10.1007/s11465-018-0483-0.
[6] Y. Koren *et al.*, 'Reconfigurable Manufacturing Systems', *CIRP Annals - Manufacturing Technology*, vol. 48, no. 2, pp. 527–540, Jan. 1999, doi: 10.1016/S0007-8506(07)63232-6.
[7] G. Michalos, N. Kousi, S. Makris, and G. Chryssolouris, 'Performance Assessment of Production Systems with Mobile Robots', *Procedia CIRP*, vol. 41, pp. 195–200, Jan. 2016, doi: 10.1016/j.procir.2015.12.097.
[8] S. Makris, G. Michalos, A. Eytan, and G. Chryssolouris, 'Cooperating Robots for Reconfigurable Assembly Operations: Review and Challenges', *Procedia CIRP*, no. 3, pp. 346–351, Jan. 2012, doi: 10.1016/j.procir.2012.07.060.
[9] G. Michalos, A. Fysikopoulos, S. Makris, D. Mourtzis, and G. Chryssolouris, 'Multi criteria assembly line design and configuration – An automotive case study', *CIRP Journal of Manufacturing Science and Technology*, vol. 9, pp. 69–87, Jan. 2015, doi: 10.1016/j.cirpj.2015.01.002.

Contact: Dr. Paul STIEF paul.stief@ensam.eu – Arts et Métiers Metz, 4 Rue Augustin Fresnel, 57078 METZ

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: EFFICIENT COMPUTATIONAL FRAMEWORK TO MODEL SIZE EFFECTS IN MINIATURIZED PRODUCTS

Topic number : ***2022_094***

Field : Material science, Mechanics and Fluids, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: MeNuIV
Research lab: LEM3 - Laboratoire d'étude des microstructures et de mécanique des matériaux
Lab location: Metz
Lab website:http://www.lem3.univ-lorraine.fr/

Contact point for this topic: Arts et Métiers

Advisor 1: Abed-Meraim Farid Farid.ABEDMERAIM@ensam.eu
Advisor 2: Jebahi Mohamed mohamed.jebahi@ensam.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Due to the increasing trend towards miniaturization, micro-scaled products have become widely used in various high technology fields, such as microelectronics and microbotics. However, when decreasing the geometrical size, several parameters, e.g., grain size and number of shallow grains, remain unchanged. This may result in modifying the mechanical properties of materials. As experimentally observed, in the size range between hundreds of nanometers and few tens of micrometers, the strength of materials is no longer scale-independent and the peculiar phenomenon “smaller is stronger” appears. Conventional plasticity theories cannot predict size-dependent behavior of materials, due to the lack of internal length scale(s). To overcome limitations of these theories, gradient-enhanced plasticity approaches have been proposed. These approaches, which are relatively recent, present very attractive features in capturing different kinds of size effects, making them one of the major scientific focuses of today. In this context, a flexible 2D gradient-based numerical tool has been developed in small and finite deformation frameworks. This tool has been successfully applied to study challenging size-dependent phenomena in ultra-thin sheet metals. The very interesting results obtained by this tool have motivated the present PhD

project, which aims at developing an optimized 3D extension of this numerical tool. To achieve its objectives, this project is divided into three parts. First, an enhanced gradient-plasticity model will be developed, considering the recent progress made on the gradient-based description of size effects. Then, the proposed model will be implemented using accurate numerical techniques within the gradient-based numerical platform (COMEP) developed by the project team. Finally, the implemented model will be applied to study challenging small-scale problems, particularly formability of ultra-thin sheet metals. The project developments will offer to the scientific and industrial communities an original and powerful numerical tool that can be used for numerous breakthrough applications, like numerical optimization of the microstructure of miniaturized products. This has numerous economic, environmental, and social benefits in terms of design and fabrication of more effective industrial components.

Required background of the student: Mechanical engineering

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Jebahi, M. Forest, S. (2022). An alternative way to describe thermodynamically-consistent higher-order dissipation within strain gradient plasticity. Journal of the Mechanics and Physics of Solids (accepted for publication)
2. Jebahi, M., Forest, S. (2021). Scalar-based strain gradient plasticity theory to model size-dependent kinematic hardening effects. Continuum Mechanics and Thermodynamics, 33, 1223-1245.
3. Ben Bettaieb M. Abed-Meraim F. (2021). Formability prediction of substrate-supported metal layers using a non-associated plastic flow rule. Journal of Materials Processing Technology, 287:116694
4. Cai, L.; Jebahi, M.; Abed-Meraim, F. (2021). Strain Localization Modes within Single Crystals Using Finite Deformation Strain Gradient Crystal Plasticity. Crystals, 11, 1235.
5. Jebahi M., Cai L., Abed-Meraim F. (2020). Strain gradient crystal plasticity model based on generalized non-quadratic defect energy and uncoupled dissipation. International Journal of Plasticity, 126:102617

Illustrations :

ParisTech

TITLE: MOLTEN SALT CONVERSION OF PLASTICS INTO HYDROGEN

Topic number : ***2022_096***

Field : Chemistry, Physical chemistry and Chemical Engineering, ,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Interfaces — Electrochemistry — Energy
https://www.ircp.cnrs.fr/la-recherche/equipe-mim2/
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.ircp.cnrs.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: LAIR Virginie virginie.lair@chimieparistech.psl.eu
Advisor 2: SEMETEY Vincent vincent.semetey@chimieparistech.psl.eu
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: In recent decades, the world has been concerned about the environmental impact of waste plastic requiring their recycling. The mechanical recycling techniques fails to treat the majority of waste plastics. Only 32% of plastics are recycled in EU. The recycling of plastic wastes (particularly low grade plastics) is challenging in the absence of a strong economic driving force. Such a driving force can be achieved through the low-cost conversion of plastic wastes into highly valuable outputs like the production of fuel. In this project we want to investigate the conversion of plastics employing molten salts to valuable materials such as hydrogen (Flandinet et al.), carbonates, carbon nanomaterial (Kamali et al.), fuel (Bertolini et al.)... To achieve this goal, model molecules as well as polymers will be studied to properly identify the products and optimize the conditions as well as the reactor. Simulations taking into account the enthalpies of reactions that can be carried out and associated with DSC-ATG analyzes. The effects of temperature, salt composition will be studied, and the yield and the composition of solid/liquid/gas products will analyzed. The system will be design in order to be able to check the mass balance and an energy balance would be carried out as well.

Required background of the student: Chemistry, Physical chemistry, Polymer chemistry, Chemical engineering

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Flandinet L., Tedjar F., Ghetta V., Fouletier J. J Hazard Mater. 2012, 485-490

2. Kamali A. Green Production of Carbon Nanomaterials in Molten Salts and Applications. Springer 2020, 109-140

3. Bertolini J., Fontaine J. Conservation & Recycling 1987, 10, 331-343

4. Zhao L., Semetey V. ACS Omega 2021, 6, 6, 4175–4183

5. Meskine H., Albin V., Cassir M., Ringuedé A., Lair V. International Journal of Hydrogen Energy 2021, 46, 14944-14952

Illustrations :

ParisTech

TITLE: 3D TWO-PHOTON POLYMERIZATION OF SMART MATERIALS

Topic number : ***2022_097***

Field : Chemistry, Physical chemistry and Chemical Engineering, Life and Health Science and Technology,

Subfield:

ParisTech School: Chimie ParisTech - PSL
Research team: Matériaux, Interfaces et Matière Molle
https://www.ircp.cnrs.fr/la-recherche/equipe-mim2/
Research lab: IRCP - Institut de Recherche de Chimie de Paris
Lab location: Paris
Lab website:https://www.ircp.cnrs.fr

Contact point for this topic: Chimie ParisTech - PSL

Advisor 1: SEMETEY Vincent vincent.semetey@chimieparistech.psl.eu
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Implantable medical devices are increasingly important in the practice of modern medicine. Unfortunately, almost all medical devices suffer to a different extent from adverse reactions, including inflammation, fibrosis, thrombosis and infection due to protein adsorption or cell adhesion. Here we propose to design new biofunctional polymers and engineer innovative smart surfaces with controlled surface property (physical and chemical characteristics) to kill bacteria or reduce protein adsorption and cell interactions and subsequently improve implant biocompatibility.
Our main interest is the synthesis of new polymers obtained by radical polymerization through both rational design and combinatorial chemistry using several moieties (e.g. quaternary ammonium salts, zwiterionic or oligoethylene glycol derivatives, N-Isopropylacrylamide...). Different polymeric architectures will be investigated for their ability to modify surface properties (plastics, metals). We will as well take advantage of two-photon photopolymerisation to generate 3D microtopographies to obtain responsive materials.
This work will be done in collaboration with Institut Curie for the biological evaluation of the generated materials.

Required background of the student: chemistry, physical chemistry, polymer chemistry

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Mussard W., Kebir N., Kriegel I., Estève M., Semetey V., Angewandte Chemie Int. Ed. Engl. 2011, 50, 10871-10874.

2. Oberleitner B., Dellinger A., Déforet M., Galtayries A., Castanet A.-S., Semetey V. Chemical Communications 2013, 49, 1615-1617.

3. Chauhan A., Bernardin A., Mussard W., Kriegel I., Estève M., Ghigo J. M., Beloin C., Semetey V. The Journal of Infectious Diseases. 2014, 210, 1347-56.

4. Coscoy S., Baiz S., Octon J., Rhoné B., Perquis L., Tseng Q., Amblard F., Semetey V. Biointerphases. 2018,13, doi: 10.1116/1.5024601.

5. Ucla P., Ju X., Demircioglu M., Baiz S., Muller L., Germain S., Monnot C., Semetey V., Coscoy S. Int J Mol Sci. 2022, 23, 2415.

Illustrations :

ParisTech

Arts et Métiers Sciences et Technologies

TITLE: DEVELOPMENT OF A DIGITAL TWIN OF THE ROBOTIZED INCREMENTAL SHEET FORMING PROCESS USING VIRTUAL REALITY

Topic number : ***2022_098***

Field : Information and Communication Science and Technology, Energy, Processes, Material science, Mechanics and Fluids

Subfield:

ParisTech School: Arts et Métiers
Research team:
Research lab: LAMPA - Laboratoire angevin de mécanique, procédés et innovation
Lab location: Angers
Lab website:https://lampa.ensam.eu

Contact point for this topic: Arts et Métiers

Advisor 1: Dal Santo Philippe philippe.dalsanto@ensam.eu
Advisor 2: Tiba Idriss idriss.tiba@ensam.eu
Advisor 3: Chevret Sandra sandra.chevret@ensam.eu
Advisor 4: Ayed Yessine yessine.ayed@ensam.eu

Short description of possible research topics for a PhD: Robotized Incremental Sheet Forming (ISF) process can be considered as a key process for the production of deep-drawn parts. The process consists gradually deforming a blank using a tool, controlled in position and orientation. The local deformation of the metal sheet associated with the tool path allows to obtain the desired shape of the part. This process has been developed since the 1960's, but only the technological advances in the fields of robotized machines and prediction and control tools allow us to consider its industrial development.
A few years ago, Metz and Angers campuses of ENSAM have explored the performance of the robotized ISF process for the production of specific lightweight metal parts. The results show the interest of using accurate simulation models to improve the prediction of the forming process, in terms of forming forces and the quality and mechanical behavior of the workpiece.
In the proposed work, numerical simulation models of the process will be used to build the digital twin of the robotic ISF cell using virtual reality techniques. This model will be developed using parameter sets for the production of specific cases. Therefore, it will be possible to interact and

visualize the forming of the different parts as well as the evolution of their mechanical behavior in real time.
Multi-sensorial metaphors (image, haptic and sound) will be developed to help the user to analyze the process. These metaphors can be adapted to the user's profile (beginner, expert).
The interactive 3D interface will be adapted to meet the needs of prospective user profiles. In a product development context, the gain is based on two uses: The first use concerns the customer having a part to produce. The latter must be able to discuss with the ISF engineering teams. Combining the expert tool (the metamodel) with an immersive interface to visualize its results offers a more complete digital chain to quickly test feasibility, identify stress fields or risks of damage, surface finish defects and ensure good communication between customers and process experts. A second use, still in 3D real time but not immersive, and more advanced with functionalities and data to be visualized, will help the business expert to save time in the iterations of the development cycle.

Required background of the student: Numerical simulation, programming, forming processes

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Z. Feng et al. Towards a customizable immersive virtual reality serious game for earthquake emergency training. Advanced Engineering Informatics, Volume 46, 2020.

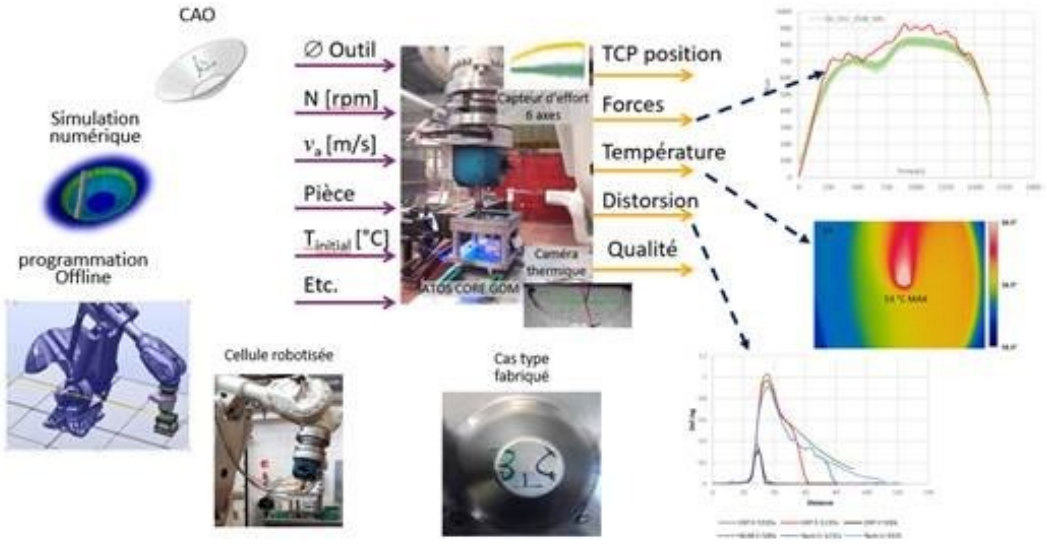
2. S. Boudhaouia et al. Experimental and numerical study of a new hybrid process: multi-point incremental forming (MPIF). International Journal of Material Forming (2018), 11; 815–827.

3. N. Vaughan et al. An overview of self-adaptive technologies within virtual reality training. Computer Science Review, Volume 22, 2016, Pages 65-87.

4.

5.

Illustrations :


CAO
Simulation numérique
programmation Offline
∅ Outil
N [rpm]
v_a [m/s]
Pièce
$T_{initial}$ [°C]
Etc.
Capteur d'effort 6 axes
Caméra thermique
TCP position
Forces
Température
Distorsion
Qualité
Cellule robotisée
Cas type fabriqué

ParisTech

Arts et Métiers

TITLE: HYBRIDIZATION OF PEM HYDROGEN FUEL CELL AND SUPERCAPACITORS FOR MARITIME APPLICATIONS

Topic number : ***2022_099***

Field : Energy, Processes, ,

Subfield:

ParisTech School: Arts et Métiers
Research team: Energy efficiency https://lispen.ensam.eu/user/72
Research lab: LISPEN - Laboratoire d'ingénierie des systèmes physiques et numériques
Lab location: Aix-en-Provence
Lab website:https://lispen.ensam.eu/user/72

Contact point for this topic: Arts et Métiers

Advisor 1: Garambois Pierre pierre.garambois@ensam.eu
Advisor 2: Roucoules Lionel lionel.roucoules@ensam.eu
Advisor 3: HUET Florian florian.huet@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: In the context of global warming, the use of alternative means of propulsion is necessary in order to reduce the GreenHouse Gas (GHG) emissions of the transportation sector. For this, many propulsions systems are based on electric motors coupled with a chemical battery energy storage. It has been proved to be efficient in certain contexts, but the battery storage also has some environmental drawbacks such as the material and metals consumption, and the weight. Another growing option is the use of Hydrogen Fuel Cell (FC), and especially the PEM technology. PEMFC present many advantages such as environmental features (less GHG emissions, less materials), low weights and a high autonomy. Nevertheless, they also show the disadvantage of a short working range of use in order to preserve its lifetime and efficiency. Other energy system such as supercapacitors used intermittently may compensate tis drawback trough a fast response.
This research project aims at developing energy modelization of the hybridization of PEMFC and supercapacitors for the purpose of maritime application. The simulations will have to take into account short-term phenomenon as well as long-term effects, and need to consider electrical, chemical and mechanical fields, in order to fit the maritime specificities.

Once mastered, these models and simulations will be used in optimization algorithms in order to find the good technical parameters combination that suits the maritime sector.

Required background of the student: Energetics, Engineering, Computer science

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. N. Dougier, P. Garambois, J. Gomand and L. Roucoules, « Multi-objective non-weighted optimization to explore new efficient design of electrical microgrids», Applied Energy, Volume 304, 15 December 2021, 117758.
2. N. Dougier, P. Garambois, J. Gomand and L. Roucoules, « Systemic approach for local energy mix assessment », Proceedings of JCM 2020, Aix-en-Provence.
3. T. Amoretti, F. Huet, P. Garambois, L Roucoules, « Multi-objective optimisation of technical wind turbines parameters based on multi-physical models », ICREPQ, Jul 2022, Vigo, Spain.
4. 4. S. Ait Hammou Taleb, D. Brown,J. Dillet,P. Guillemet,J. Mainka,O. Crosnier,C. Douard,L. Athouël,T. Brousse,O. Lottin, « Direct Hybridization of Polymer Exchange Membrane Surface Fuel Cell with Small Aqueous Supercapacitors », 7th International Conference on Fundamentals & Development of Fuel Cells (FDFC2017), 2017, Stuttgart.
5.

Illustrations :

TITLE: PRODUCTION OF STRIKING VISUAL APPEARANCE WITH DISORDERED METASURFACES

Topic number : ***2022_100***

Field : Physics, Optics, ,

Subfield:

ParisTech School: Institut d'Optique Graduate School
Research team:
Research lab: LP2N - Laboratoire Photonique, numérique et nanosciences
Lab location: Bordeaux
Lab website:https://www.lp2n.institutoptique.fr/light-complex-nanostructures

Contact point for this topic: Institut d'Optique Graduate School

Advisor 1: Lalanne philippe Philippe.lalanne@institutoptique.fr
Advisor 2:
Advisor 3:
Advisor 4:

Short description of possible research topics for a PhD: Optical metasurfaces are currently receiving a lot of attention from academic laboratories and industries. A broad range of applications, from quantum studies to imaging and holography, are considered woldwide.

The present project explores a new application of metasurfaces to generate new iridescences (or appearances) that are not encountered in nature, see our recent publication: Vynck et al. , Nature Materials 21, 1035–1041 (2022).

For that, we have developed a numerical platform, which mixes nanoscale electrodynamics, mesoscale multiple scattering and macroscale rendering (as used in computer graphics). The platform allows us to model the scattering properties of random monolayers composed of resonant nanoparticles (a challenge) and to generate true-to-life synthetic images of arbitrary objects (cell phones, cars, rings) covered by random metasurfaces. This new tool in nanophotonic clearly indicate the high potential of random metasurfaces to produce unusual visual effects. We

would like to push the investigation further and to fabricate the metasurfaces and observe their appearances.

Required background of the student: nanophotonics

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. K Vynck, R Pacanowski, A Agreda, A Dufay, X Granier, P Lalanne, Nature Materials 21, 1035–1041 (2022)
The visual appearances of disordered optical metasurfaces
2. C Gigli, Q Li, P Chavel, G Leo, ML Brongersma, P Lalanne, Laser & Photonics Reviews 15 (8), 2000448 (2021)
Fundamental limitations of Huygens' metasurfaces for optical beam shaping
3. L Roach, A Hereu, P Lalanne, E Duguet, M Tréguer-Delapierre, K Vynck, Nanoscale 14, 3324-3345 (2022)
Controlling disorder in self-assembled colloidal monolayers via evaporative processes
4. H Benisty, JJ Greffet, P Lalanne, Oxford University Press (2022)
Introduction to Nanophotonics
5.

Illustrations :

TITLE: RISK MANAGEMENT OF ENGINEERING PRODUCTS DRIVEN BY ARTIFICIAL INTELLIGENCE

Topic number : ***2022_101***

Field : Design, Industrialization, ,

Subfield: Industrial Engineering

ParisTech School: Arts et Métiers
Research team: http://lcfc.ensam.eu/
Research lab: LCFC - Laboratoire de conception, fabrication, commande
Lab location: Metz
Lab website:http://lcfc.ensam.eu/

Contact point for this topic: Arts et Métiers

Advisor 1: SIADAT Ali ali.siadat@ensam.eu
Advisor 2: PETRONIJEVIC Jelena jelena.petronijevic@ensam.eu
Advisor 3: ETIENNE Alain alain.etienne@ensam.eu
Advisor 4:

Short description of possible research topics for a PhD: With the pace of technological development, the complexity of industrial products is increasing. As a result, its risk management is becoming demanding and data-driven risk models are needed. However, the adoption of these approaches is still slow as risk management is highly dependent on experts whose knowledge is often captured in textual and descriptive form (e.g. FMEA and risk register) including at the same time the source of risk, interaction and effect. Building the model based on this form requires understanding of human perception and communication.
The aim of this thesis is to bridge the gap between the conventional way in which risks are represented and the desired model-based risk management. More specifically, the research involves risk identification and analysis with the use of artificial intelligence conducted in two phases. Beginning with text-based risk knowledge, the objective is to apply deep learning techniques (e.g. natural language processing) to the identification of risk drivers. Based on this step, the risk model of the engineering product is to be developed. The thesis therefore leads towards automated risk management, which minimizes the costs and time required for this process.

Required background of the student: Industrial engineering, Computer science

A list of 5 (max.) representative publications of the group: (Related to the research topic)

1. Azarian, A., Siadat, A., & Martin, P. (2011). A new strategy for automotive off-board diagnosis based on a meta-heuristic engine. Engineering Applications of Artificial Intelligence, 24(5), 733-747.
2. Mili, A., Bassetto, S., Siadat, A., & Tollenaere, M. (2009). Dynamic risk management unveil productivity improvements. Journal of Loss Prevention in the Process Industries, 22(1), 25-34.
3. Petronijevic, J., Etienne, A., & Siadat, A. (2022). Global risk assessment for development processes: from framework to simulation. International Journal of Production Research, 1-25.
4. Petronijevic, J., Etienne, A., & Dantan, J. Y. (2019). Human factors under uncertainty: A manufacturing systems design using simulation-optimisation approach. Computers & Industrial Engineering, 127, 665-676.
5. Shah, L. A., Etienne, A., Siadat, A., & Vernadat, F. (2016). Decision-making in the manufacturing environment using a value-risk graph. Journal of Intelligent Manufacturing, 27(3), 617-630.

Illustrations :