ParisTech

École des Ponts ParisTech

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Mathematics and their applications

Subfield: Applied mathematics (scientific computing), Computational mechanics (hydraulics)

Title: Modelling and simulating complex flows for engineering puposes

ParisTech School: Ecole des Ponts ParisTech

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Short description of possible research topics for a PhD:

Continuum mechanics has provided engineers with models that are useful for numerous quantitative predictions. Navier-Stokes or Saint-Venant equations e.g. provide one with realistic numerical simulations of *fluid* flows in various practical situations. But real flows are complex, even water : in river floods for instance. And engineers are mostly interested by particular *real* situations, with specific features that are well observed but not easily predicted yet using generic models like Navier-Stokes or Saint-Venant : heat fluxes, the mixing of chemical species, the rheology of non-Newtonian fluids, the fluctuations in turbulent flows etc. That is why one keeps developing new flow models, on adding complexities to standard models.

At LHSV, given recent improved measurements of real fluid flows (see [5] and Illustration 1. below for an example regarding floods), we aim at validated new flow models, with a better quantitative description than standard models in specific engineering situations. Numerical simulations are verified first, and a sound mathematical framework is required to that aim.

Possible research topics are the construction of new models for complex flows with Partial Differential Equations (PDEs) [2,4], the construction of numerical schemes [1] (for mathematically inclined students) and the numerical simulation of new models [3] (for computer inclined students).

Required background of the student:

PDEs applied to field theories in physics (mechanics preferably), discretization methods (Finite-Volume/Finite-Element), numerical analysis, scientific computing (with Python/C++)

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

1. John Barrett, Sébastien Boyaval, Finite element approximation of the FENE-P model, *IMA Journal of Numerical Analysis* (OUP), 2017
2. Sébastien Boyaval, Viscoelastic flows of Maxwell fluids with conservation laws, working preprint https://hal-enpc.archives-ouvertes.fr/hal-02908379 , 2020
3. Sébastien Boyaval, Alexandre Caboussat, Arwa Mrad, Marco Picasso, Gilles Steiner, A semi-Lagrangian splitting method for the numerical simulation of sediment transport with free surface flows, *Computers and Fluids, 2018 172*
4. François Bouchut, Sébastien Boyaval, Unified derivation of thin-layer reduced models for shallow free-surface gravity flows of viscous fluids, *European Journal of Mechanics - B/Fluids*, 2016
5. Sébastien Proust, Céline Berni, Martin Boudou, Antoine Chiaverini, Victor Dupuis, et al.. Predicting the flow in the floodplains with evolving land occupations during extreme flood events (FlowResANR project) 3rd European Conference on Flood Risk Management, Oct 2016, Lyon, France. Hal-01585278

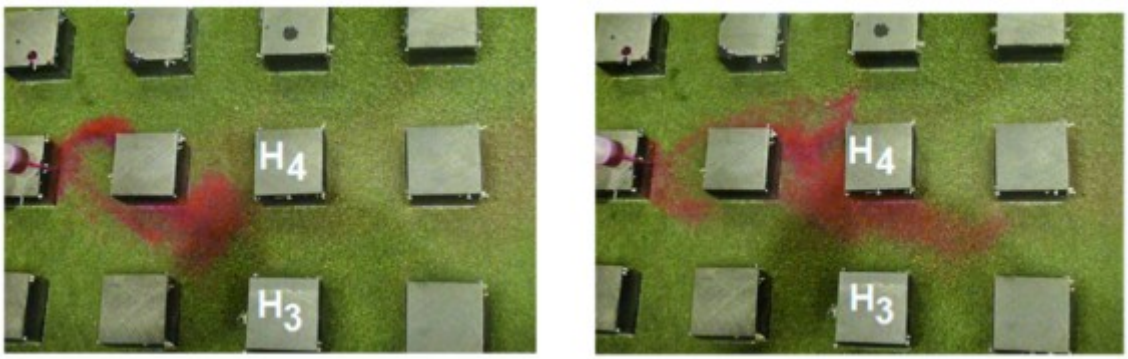

Illustration 1: PhD thesis of Marina Oukacine (p. 116). Étude expérimentale et numérique des écoulements à surface libre en présence d'obstacles émergés et faiblement submergés. Université Paris-Est, 2019. tel-02948861