Master 2 internship proposal

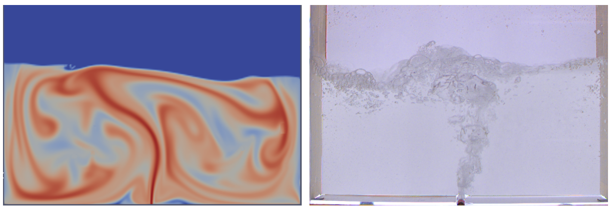
Physique et Mécanique des Milieux Hétérogènes

Contact: Stéphane Perrard, Sophie Ramananarivo, Marc Vacher
@: stephane.perrard@espci.fr sophie.ramananarivo@polytechnique.edu marc.vacher@polytechnique.edu

Internship location: PMMH & LadHyX
Phd opportunity : No
Possibility of M1 internship: Yes

Jet-induced sloshing instability : a glass industry problem

Saint-Gobain designs, produces, and markets mineral insulation materials such as stone wool, which provide comfort and thermal performance for buildings, vehicles, and infrastructure. The materials used to manufacture rock wool can be melted using several furnace technologies before being fiberized into wool. Some of these technologies involve coupled phenomena between flame jets and molten rock baths, which can trigger hydrodynamic instabilities. These instabilities represent a challenge for the stable operation of the process, which is why it is essential to develop a detailed understanding of the physics of the stirred glass bath.



Left : Basilisk simulation of a monophasic jet under a free surface (colors represent passive tracers). Right : Picture of the experimental setup showing an air jet injected into a water bath.

In the laboratory, a model system was developed to reproduce the behavior of a flame jet, using an air bubble jet injected into a water bath that models the glass melt. This experimental setup successfully replicated the instabilities observed in glass furnaces, characterized by surface sloshing of the bath coupled with lateral jet oscillations.

Building on this experimental foundation, the internship will focus on a numerical investigation of the underlying physical mechanisms driving these instabilities. Preliminary simulations conducted with the open-source solver *Basilisk* (`https://basilisk.fr/`) modeled a simplified two-dimensional free-surface configuration impinged by a water jet (without bubbles) and captured a significant portion of the experimentally observed dynamics. The work will consist in improving these simulations and performing convergence analyses to ensure their robustness. We will then analyze the resulting flow fields to develop and validate reduced-order models, compare them with analytical predictions, and study how the instability dynamics depend on key physical parameters.

Expected skills: A solid background in fluid mechanics or soft matter physics, along with basic programming skills (e.g., Python, MATLAB, or C); Interest in numerical simulation; Prior knowledge of hydrodynamic instabilities and experience with CFD or open-source solvers is a plus;