PhD Thesis Offer at the University of Lille and IMT Nord Europe – October 2025

Thermo-Convective Instability in Suspension Flow (THECOS)

Context and Objective:

The intensification of energy exchanges is a major challenge for decarbonization: how can we efficiently regulate the thermal behavior of industrial or electronic components while minimizing the energy required for this regulation? The THECOS project focuses on the study of heat transfer in dispersed media as a tool for this intensification, allowing the promotion and/or control of convective-conductive instabilities and transfers. The influence of the physical and morphological properties of particles on heat transfer will be studied in relation to the various dynamic phenomena associated with two-phase flow: hydrodynamic instabilities, secondary flows, migration of the dispersed phase, and the transfer of heat and kinetic energy.

The PhD project is structured into two complementary phases:

1. **Theoretical and Numerical Analysis:**
   The PhD candidate will conduct theoretical and numerical studies in linear and weakly nonlinear flow regimes to determine the thresholds and characteristics of instabilities that a particulate two-phase fluid may present when subjected to a thermal gradient. Direct numerical simulations (DNS) will be carried out to further explore the dynamics and transfers beyond the convection threshold, as well as in strongly nonlinear and turbulent regimes. This phase will be supervised by the Complex Fluids team at UML.

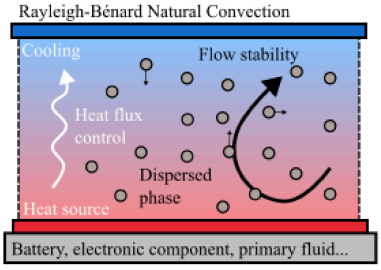

FIG. Schéma de principe du projet THECOS.

2. **Experimental Study:**
   The PhD candidate will conduct an experimental investigation in the Complex Fluid Flow laboratory of CERI EE, which specializes in characterizing the dynamics of complex fluid and suspension flows. The experiments will use a Rayleigh-Bénard cell adapted for particle injection and will focus on analyzing instability phenomena, particle segregation, and convective intensification of heat transfer. A comparison with numerical results will help validate the physical model and simulation outcomes.

Organization and Required Skills

This PhD project will be supported by a strong collaboration between the Lille Mechanics Unit and the Energy & Environment Center. It will take place at the Lille and Douai sites and will be funded by the Hauts-de-France region in partnership with both institutions.

The thesis is aimed at students with a background in physics, fluid mechanics, or thermal sciences who are interested in combining analytical, numerical, and experimental approaches. Knowledge of rheology, complex fluid dynamics, and two-phase flow would be beneficial but is not a prerequisite.

Supervisors:

Silvia HIRATA (University of Lille), Enrico CALZAVARINI (University of Lille), Amir BAHRANI (IMT Nord Europe) Tom LACASSAGNE (IMT Nord Europe)

Application Procedure:

Send a detailed CV, a cover letter, the names and emails of at least two referees willing to provide a recommendation letter, and any other supporting documents to: silvia.hirata@univ-lille.fr, amir.bahrani@imt-nord-europe.fr