PhD GRANT

ÉCOLE DOCTORALE SCIENCES EXACTES ET LEURS APPLICATIONS - ED 211 / NATURAL SCIENCES DOCTORAL SCHOOL

Avenue de l'université BP 1155 64 013 PAU Cedex – France

PhD SUBJECT

TITLE:

Giant Fluctuations in complex fluids in microgravity and ground conditions

ABSTRACT:

Giant non-equilibrium fluctuations are present during diffusion processes in liquid mixtures and in the presence of a heat flux through a fluid. On Earth, gravity suppresses the long wavelength fluctuation below a typical cut-off wave vector. Nowadays we have reached a satisfactory understanding about the behaviour of NE fluctuations of binary liquid mixtures with small external gradients applied. The aim of this PhD study is the investigation of non-equilibrium fluctuations associated to diffusion in complex fluids in the absence of gravity on board the ISS, and in realistic conditions that cannot be easily tackled by theoretical models, such as transient diffusion, concentrated samples and large gradients, also in comparison to computational results. On-ground measurements will be used for the preparation of the in microgravity experiments and to the establishment of references values.

Keywords: Non-equilibrium fluctuations, microgravity, shadowgraphy, complex fluids

WORKING CONDITIONS

Laboratoire : Laboratoire des Fluides Complexes et leurs Réservoirs
Site web : https://lfc.univ-pau.fr/fr/index.html

PhD Director: Fabrizio Croccolo, HdR (fabrizio.croccolo@univ-pau.fr)
PhD co-Director: Henri Bataller, HdR (henri.bataller@univ-pau.fr)
In Collaboration with:
Alberto Vailati (Università degli Studi di Milano - IT)
José Ortiz de Zarate (Universidad Complutense, Madrid - ES)

Place: LFCR - Anglet (FR)

Starting date: October 2018	**Duration: 3 years**

Employer: CNES – UPPA

Monthly salary before taxes: TBD €

HOST LABORATORY PROFILE

LFCR: From the nanometer to hundreds of kilometers, from the nanosecond to a million years, from the physics and chemistry of interfaces, through the thermodynamics of fluids under flow, to reservoir geology, geomechanics and geophysics, status as an "industrial" UMR (Joint Research Unit), supervised by TOTAL, the CNRS and the UPPA, the LFCR is an innovative and remarkable research unit in more than one way. Its specific focus, essentially based on the study of fossil georesources, and totally in phase with the local socio-economical context, sets it apart regarding applications and enables it to host internationally-recognized teams.

MISSION – PRINCIPAL ACTIVITIES

I. *Scientific Context*

Fluids under Non-Equilibrium (NE) conditions show long-range fluctuations whose intensity diverges at small wave vectors. This divergence is limited by the gravity and/or the confinement exerted by the walls containing the fluid. Light scattering analysis of NE fluctuations allow us measuring transport properties of the fluid. Diffusion occurs in a wide variety of physical and chemical processes. Nowadays we have reached a satisfactory understanding about the behaviour of NE fluctuations of binary liquid mixtures. However, the vast majority of fluids are essentially multi-component and/or contain a significant number of chemical compounds of different molecular weights and sizes. Experimental studies on the NE fluctuations in complex fluids remain rare and only deal with solutions of diluted polymers or colloidal dispersions. A great interest is currently devoted to ternary mixtures also through the international space projects DCMIX and SCCO. Although the experimental and theoretical difficulties increase considerably with the number of chemical constituents, ternary mixtures remain a further and natural step in multi-component mixtures: they exhibit characteristics of truly multi-constituent systems, such as cross-diffusion, diffusion barriers or osmotic diffusion.

The Giant Fluctuations space project (also called NEUF-DIX) aims at studying the phenomena governing fluctuations in NE complex fluids and developing analysis tools for the metrology of transport coefficients in complex fluids. In order to avoid any disturbances due to convection generated by the temperature or concentration gradients, a gravity-free environment is necessary for carrying out the experiments described in the project. By analysing the light scattered by the transparent dielectric samples, density fluctuations of the fluids can be studied experimentally by recording series of images that are eventually statistically analysed by means of 2D Fourier analysis and a differential dynamic algorithm. Form this analysis one can extract the temporal correlation function of the system and then measure mass diffusion and Soret coefficients of binary or ternary mixtures. The procedure can also be used to validate the theory of the NE fluctuations in complex fluids.

II. *Objectives*

The PhD candidate will contribute to the development of the diagnostics involved in the NEUF-DIX project. The new setup will involve a two-wavelength dynamic shadowgraph. The current Shadowgraph setup makes use of a light source of low temporal coherence (Super Lumen, SLD-MS-261-MP2-SM, $\lambda = 675 \pm 13$ nm), and a relatively fast camera (Hamamatsu ORCA Flash V4, sCMOS, 200Hz at 1024x1024pixels), recently acquired. In order to modify our setup to two wavelengths a beam splitter and the system of acquisition of two images at the same time Hamamatsu W-Gemini and a light source with lambda of 405nm have been recently added. The setup we have developed is the basis for the setup development of the NEUF-DIX project.

III. *Work plan*

The selected PhD student will integrate the team working on the NEUF-DIX project at the LFCR laboratory at the Anglet site of UPPA. Specifically, he/she will contribute to the realisation and validation of the two wavelengths shadowgraph setup as applied to the investigation of fluctuations in ternary mixtures. He/she will perform extensive on-ground measurements on different samples including polymers at different concentrations in binary solvents with the developed technique. The on-ground measurements will serve as guideline for the further definition of the samples and experimental conditions for the series of experiments foreseen during the project on-board the ISS in the next 5 years. The latter data will be finally compared with those obtained in microgravity conditions in order to validate existing theories and/or provide hints for their further development.

IV. *References*

- Croccolo, Bataller and Scheffold, J. Chem. Phys. **137**, 234202 (2012)
- Ortiz de Zárate and Sengers, Hydrodynamic Fluctuations in Fluids and Fluid Mixtures (Elsevier, Amsterdam, 2006)
- Croccolo et al., Eur. Phys. J. E **39**, 125 (2016)
- Vailati et al., Nat. Commun. **2**, 290 (2011)
- Cerbino et al., Sci. Rep. **5**, 14486 (2015)
- Croccolo et al., Micrograv. Sci. Technol. **28**, 467 (2016)
- Croccolo et al., Ann. N.Y. Acad. Sci. 1077, 365 (2006)
- Croccolo et al., Phys. Rev. E **99**, 012602 (2019)
- García-Fernández et al., Eur. Phys. J. E **42**, 124 (2019)
- Baaske et al., Eur. Phys. J. E **39**, 119 (2016)
- Croccolo and Brogioli, App. Opt. **50**, 3419 (2011)

REQUIRED COMPETENCES

The candidate must hold a master or equivalent degree with majors in physics with a strong background in fluid mechanics etc. Experiences with optical techniques and/or image analysis will be a plus. Good knowledge in English and good writing skills are required.

CRITERIA USED TO SELECT CANDIDATE

Selection process steps:
- Establishment of the selection comittee.
- Evaluation of the applicants cv's.
- Interview with the selected candidates and ranking.

Criteria used in selection of the candidate:
- The candidate's motivation, scientific maturity and curiosity.
- Candidate knowledge in optics and experimental fluid dynamics.
- Candidate marks and rankings in M1 and M2.
- English proficiency.

REQUIRED DOCUMENTS, DEADLINE

- Apply online at : https://recrutement.cnes.fr/en/annonce/898930-138-giant-fluctuations-in-complex-fluids-in-microgravity-and-ground-conditions-64000-pau

Deadline:	**31/03/2020**

CONTACTS

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