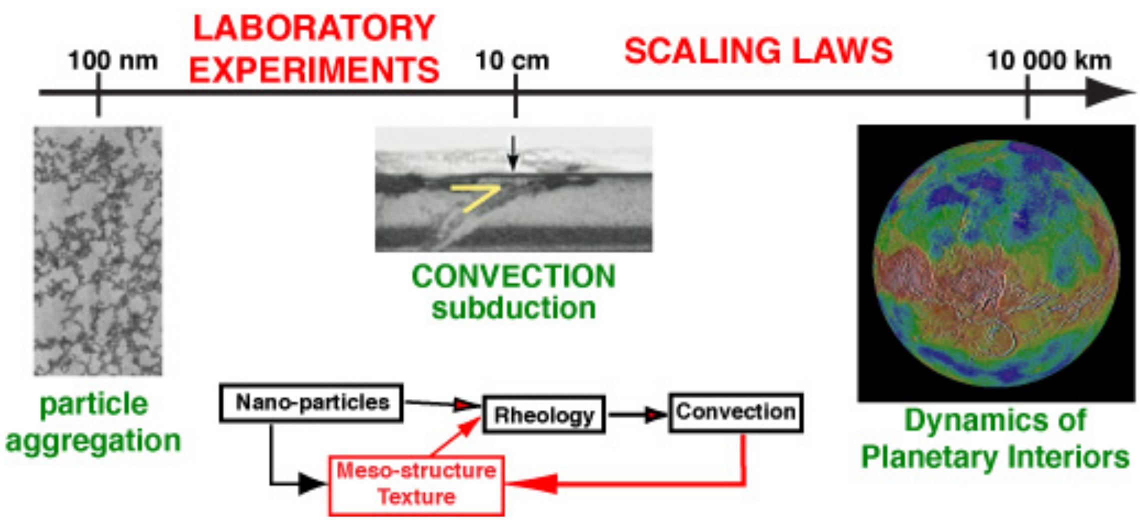
Influence of the meso-scale texture on convective patterns in complex fluids: from laboratory to planets.

Ph_D Thesis from project MESOPLANET-2, fiunded by LABEX PALM of University Paris-Saclay.

Beginning = September 2021, for 36 months

<u>Context:</u> Rayleigh-Bénard convection develops when a plane layer of fluid is heated from below and cooled from above. Ubiquitous for mass and heat transfers in many industrial systems, it has also been identified as a major feature of the dynamics of the interior of stars and planets, and of the oceans and the atmosphere. A large body of theoretical and experimental work exists for fluids with constant viscosity. However, rocky planets, icy satellites, lava flows, bacteria solutions, colloidal dispersions and molecular glasses all share an important property : the variation of a control parameter,- such as temperature, light, concentration, or ionic content-, can induce arrest and/or gelation of their microstructure and a drastic increase of their viscosity. So convection develops in a sublayer under a « lid », or skin, that takes up most of the viscosity variation. This lid remains stagnant and strongly limits heat and mass transfer across the surface. However, the skin very often has also solid-like properties and can develop shear banding, wrinkles and even cracks. This texture at the meso-scale will affect the skin interaction with convection and the large-scale dynamics of the layer. These in turn will affect skin formation and texture. This interplay of the micro-meso-macro structures govern the evolution of rocky planets, the formation of biological mats, or of milk skin. Plate Tectonics on Earth, whereby 60% of the Earth surface is continuously renewed, is an exemple of the skin breaking and sinking back in the convective layer. But it is probably only one convective pattern/regime among many.



Methods: Aqueous colloidal silica suspensions will be used as a model system, where the nanoparticles size and volume fraction can be tuned to control rheology and induce aggregation. The work will combine fluid mechanics convection experiments, and state-of-the-art visualization and measurements techniques from nano- to cm-scales (neutron imagery, X-rays and neutrons diffraction, DLS, Raman and IR spectroscopy, rheology, thermography, LIF and PIV).

Objectives: This thesis aims at: A) study the influence of the meso-scale structuration of the skin on the convective regimes in colloidal silica suspensions ; B) acquire a better understanding on the link between texture, water content and rheology ; C) provide a phase diagram of the different convective regimes in such complex fluids ; D) use those results and the associated scaling laws to better constraint the dynamics of planetary interiors.

Key words: Convection, Rheology, Colloids, Planets, Scaling laws, 3D Imagery, Laboratory experiments, Fluid Mechanics.

Profile and skills required: Applicants must have strong quantitative and scientific background, hold a Master degree in fluid mechanics, soft matter physics, material sciences, or geophysics, and be highly motivated to work in an pluri-disciplinary team. They should also have an interest for experimental work and/or 3D imagery.

Thesis environment: This project will be carried out in a pluridisciplinary environment between FAST (fluid mechanics) and LLB (imagery, soft matter). The PhD will be co-supervised by Anne Davaille (FAST) and Christiane Alba-Simionesco (LLB).

Deadlines and Contacts: Candidates should send CV, letter of motivation and academic credentials as soon as possible and not later than **May 20, 2021** to **anne.davaille@universite-paris-saclay.fr** and **christiane.alba-simionesco@cea.fr.**

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