

Internship proposal

Laboratory: **Institut de Physique de Rennes** (IPR, UMR 6251)

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Internship location: **IPR, Université de Rennes, Campus de Beaulieu**

Level: **M2**

Thesis possibility after internship: **YES**

Funding: **YES**

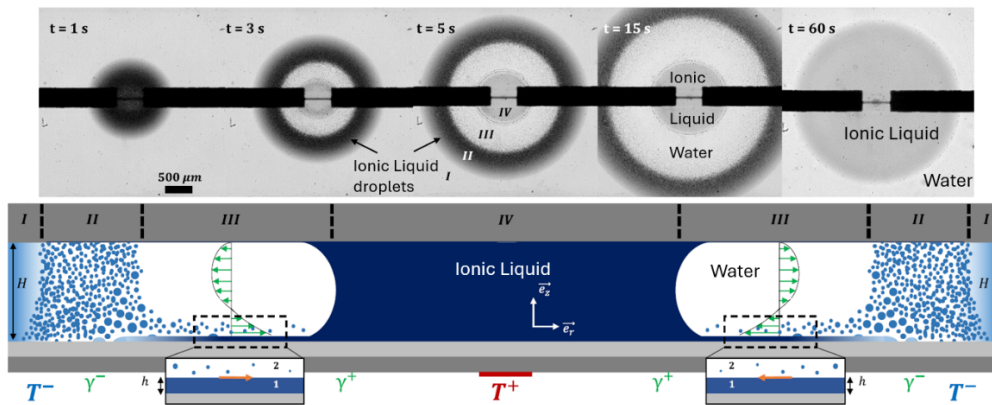
Phase separation of a thermoresponsive binary solution under flow for osmotic energy production

This project aims to recover very low-temperature waste heat ($< 60^\circ\text{C}$) by combining a thermosensitive binary solution (water + ionic liquid) with electricity production through an osmotic process. We have already demonstrated the proof of concept of this process [Pascual et al., *Energy Environ. Sci.*, 2023]. So far, we have studied the phase separation dynamics of the binary solution in a temperature gradient above a critical temperature (30°C) within a cylindrical cavity [Pascual et al., *PR Fluids*, 2021]. This led to the formation of two phases: one enriched in ionic liquid and the other in water, thereby generating a salinity gradient.

Additionally, Lydéric Bocquet's group (LPENS) characterized the mixing of these two phases when placed at the ends of a nanoporous membrane at a temperature below 30°C . This recombination occurs via diffusio-osmosis, an osmotic process driven by a salinity gradient along a charged interface (here, the nanopores) which enables the generation of an electric current. As such, heat leads to the phase separation of the binary mixture which is then converted into electrical current.

Many fundamental and technical questions remain to be addressed. One of these is to convey the two phases at the ends of the nanoporous membrane by adding a flow. The goal of the internship, is to analyze the phase separation dynamics of the binary solution in a more suitable geometry and under flow, which complicates the separation dynamics, giving rise notably to a thermocapillary instability. Taking advantage of flows at microscales, different flow strategies will also be explored. The themes associated with this project fall within the fields of soft matter and low-Reynolds hydrodynamics. The work will be experimental (microfluidic experiments, image processing), combined with modeling. The subsequent PhD thesis will involve continuing fundamental studies on these flows, while also investigating flow initiation strategies by leveraging the properties of microfluidics. The funding of the PhD is secured.

This research will be conducted as part of the ANR WATTS project, in collaboration with Lydéric Bocquet (LPENS/Collège de France, Paris) and Emmanuel Benichou (ILM, Lyon). This collaborative project ultimately proposes an innovative approach for recovering ultra-low-grade heat.



Phase separation of the binary mixture, heating is provided at the center of the cavity.