PhD position in Physics

Interfacial instability in a liquid metal battery

Liquid metal batteries represent one of the most promising solutions for large-scale energy storage, differing from standard batteries on account of their liquid electrodes. These batteries consist of three stratified liquid layers: a molten salt (electrolyte) sandwiched between two liquid metals (electrodes). They are operated at very high temperatures to keep the electrodes in a liquid state and are subject to current-induced internal heating and magnetic fields.

Liquid metal batteries have advantages in terms of kinetics, durability, and adaptability due to their liquid-state electrodes. However, as fluid systems, they can be subjected to hydrodynamic instabilities, which can limit the battery performance and even lead to short-circuiting by the rupture of the electrolyte.

This PhD will focus on the interfacial instability that can develop when an interface separating two fluids of different electrical conductivity is traversed by free currents. In liquid metal batteries, this instability may occur at both interfaces, and because the electrolyte generally has a lower thickness to limit the internal heating, it can lead to the rupture of the electrolyte. The objective of the PhD is to carry out a nonlinear stability analysis on the three-layer system to understand the conditions for the sandwiched-layer rupture. The theoretical predictions will be compared to direct numerical simulations to cross-validate the results. A multiscale tool of analysis, developed at the CORIA lab in the context of recent research on atomisation, will be applied to describe the coupling between the two interfaces of the three-layer fluid system.

The applicant should hold a Master's Degree in General Physics with a solid knowledge of fluid mechanics. Skills in stability theory will be particularly appreciated.

Funding:	LabEx EMC^3, HILIMBA project
Laboratory:	CORIA, UMR 6614, Saint Etienne du Rouvray, France
Desired starting date:	10/01/2021
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PhD position in Physics

Investigation of thermal convection in a liquid metal battery

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Liquid metal batteries represent one of the most promising solutions for large-scale energy storage, differing from standard batteries on account of their liquid electrodes. These batteries consist of three stratified liquid layers: a molten salt (electrolyte) sandwiched between two liquid metals (electrodes). They are operated at very high temperatures to keep the electrodes in a liquid state and are subject to current-induced internal heating and magnetic fields.

Liquid metal batteries have advantages in terms of kinetics, durability, and adaptability due to their liquid-state electrodes. However, as fluid systems, they can be subjected to hydrodynamic instabilities, which can limit the battery performance and even lead to short-circuiting by the rupture of the electrolyte.

This PhD will focus on thermal convection in a liquid metal battery, especially in the electrolyte and upper liquid electrode. Indeed, passing an electric current through the electrolyte can induce internal heating accompanied by a vertical temperature variation. The latter induces an unstable density stratification in the upper layer of the electrolyte, leading to thermoconvective flow above a critical value of the electric current. Moreover, the application of the magnetic field to a liquid metal with a temperature gradient will modify the conditions of the appearance of the thermal convection. The objective of the PhD is to carry out an exhaustive investigation of the conditions underlying the appearance of the thermal convection in the electrolyte depending on its diffusive properties. It will also investigate the effect of the magnetic field on the thermal convection in the upper electrode. Linear stability analysis will be used to determine the critical parameters, and direct numerical simulations will then be implemented to compute the heat transfer as a function of the control parameters.

The applicant should hold a Master's Degree in Physics or Mechanical Engineering with a solid knowledge of fluid mechanics and electromagnetism. Skills in numerical simulations are desirable.

Funding:	LabEx EMC^3, HILIMBA project
Laboratory:	LOMC, UMR 6294, CNRS-Université du Havre, France
Starting date:	10/01/2021
Contact:	Innocent Mutabazi innocent.mutabazi@univ-lehavre.fr https://www.lomc.fr/spip.php?article50