CEA Saclay –Service de Physique de l'Etat Condensé (SPEC)
Laboratoire *SPHYNX* (http://iramis.cea.fr/spec/SPHYNX/)

PhD proposition - Fall 2024

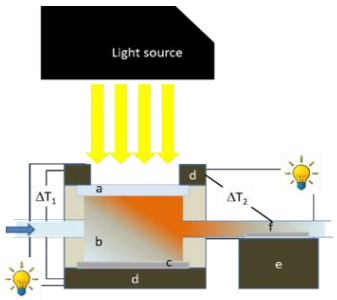
THERMOELECTRIC ENERGY CONVERSION IN COMPLEX FLUIDS
COGENERATION OF HEAT AND ELECTRICITY USING NANOFLUIDS

Thermoelectric (TE) materials that are capable of converting heat into electricity have been considered as one possible solution to recover the low-grade waste-heat (from industrial waste-stream, motor engines, household electronic appliances or body-heat). At CEA/SPEC, we explore thermoelectric effects in an entirely different class of materials, namely, complex fluids containing electrically charged nanoparticles that serve as both heat and electricity carriers. Unlike in solid materials, there are several inter-dependent TE effects taking place in liquids, resulting in Se values that are generally an order of magnitude larger that the semiconductor counterparts. Furthermore, these fluids are composed of Earth-abundant raw materials, making them attractive for future TE-materials that are low-cost and environmentally friendly. While the precise origins of high Seebeck coefficients in these fluids are still debated, our recent results indicate the decisive role played by the physico-chemical nature of particle-liquid interface.

The goal of the PhD project is two-fold :

- First, we will investigate the underlying laws of thermodynamic mechanisms behind the thermoelectric potential and power generation and other associated phenomena in nanofluids. More specifically, we are interested in how the particles' Eastman entropy of transfer is produced under the influence of thermal, electrical and concentration gradients. The results will be compared to their thermo-diffusive and optical absorption properties to be obtained through research collaborations.

- Second, the project aims to test the promising nanofluids in the proof-of-concept hybrid solar-collector devices currently developed within the group to demonstrate the co-generation capability of heat and electricity. The hybrid device optimization is also within the project's scope



Hybrid solar-thermoelectric cell developed by INO & SPHYNX. Real image not available due to the on-going patent application.

The proposed research project is primarily experimental, involving thermoelectrical, thermal and electrochemical measurements; implementation of automated data acquisition system and analysis of the resulting data obtained. The notions of thermodynamics, fluid physics and engineering (device) physics, as well as hands-on knowledge of experimental device manipulation are needed. Basic knowledge of optics and electrochemistry is a plus. For motivated students, numerical simulations using a commercial CFD software, as well as the optical absorption measurements at the partner lab (LNO/CNR, Florence, Italy) is also be envisaged.

The ideal candidate will have a strong background in Physics (thermodynamics, condensed matter, fluids) with basic theoretical/practical notion of Chemistry. Hands on experience in the laboratory environment (glovebox handling, electronic hardware manipulation, etc.) is highly desired. Advanced numerical skills are not required, but can be useful.

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REFERENCES:

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[2] E. Sani, *et al.*, "Multifunctional Magnetic Nanocolloids for Hybrid Solar-Thermoelectric Energy Harvesting," Nanomaterials, 11(4), 1031; https://doi.org/10.3390/nano11041031 (2021).
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