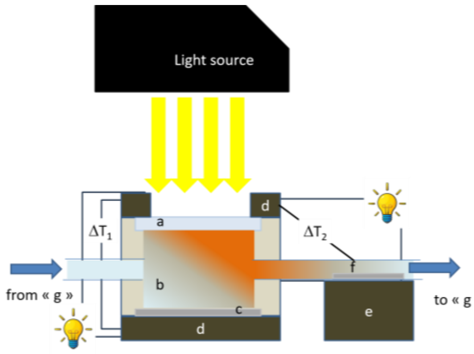
**CEA Saclay –Service de Physique de l'Etat Condensé (SPEC)**
**Laboratoire *SPHYNX* (http://iramis.cea.fr/spec/SPHYNX/)**

## PROPOSITION DE STAGE 2020/2021

# SOLAR-THERMOELECTRIC HYBRID ENERGY HARVESTING USING MAGNETIC NANOFLUIDS

Solar energy harvesting is, without a doubt, the most promising renewable energy technological path for accelerating the global carbon-exit strategy. A plethora of materials' such as semiconductors, conducting polymers, bio-inspired nanoarrays, *etc.*, are explored for converting solar radiation into electricity, heat and chemical fuels. Nanofluids (liquid suspensions of nanometer-sized additives) were first introduced to solar-thermal collector devices as a better heat carrier to improve the heat transfer efficiency[1]. More recently, certain types of nanoparticles are found to be an excellent Sun light absorber, such that even at extremely low mass fractions (*i.e.*, 0.01%-0.1% wt), they can transform the transparent heat transfer fluid into a full-volumetric solar absorbers. Due to their unique magneto-thermophysical properties[2], magnetic nanoparticles tend to form chain-like structures under the effect of applied magnetic field, improving both the heat transfer and optical properties[3], making magnetic nanofluids (MNF) a magnetically-tunable solar-absorber/heat transfer medium. Furthermore, recent studies by SPHYNX/SPEC/CEA indicated that the MNFs are thermoelectrically active; i.e., enable direct heat-to-electricity conversion[4] (https://www.magenta-h2020.eu).




Hybrid Solar/thermoelectric prototype. Solar simulator light illuminating the collector cell through (a) a glass-plate with electrodeposited transparent electrode to heat (b) the active MNF creating a temperature gradient ΔT between the top and the bottom of the cell. The thermoelectric effect takes place between the top and (c) the bottom electrodes. Temperature difference as well as the induced voltage and current will be extracted via (d) stainless steel covers. Slow fluid flow is produced by a peristaltic pump drive to transport the heated fluid to be cooled by (e) a heat exchanger. In this configuration ΔT is also produced between the cell and the heat exchanger, and (f) an additional electrode is introduced to recover extra heat energy.

At SPHYNX, we have recently started a research project to explore the bespoke multi-functionality of magnetic nanofluids with a long-term goal to demonstrate a novel hybrid solar collector capable of co-generating heat and electricity. The proposed internship project is dedicated to the development and the optimization of the proof-of-concept hybrid solar-collector device through rigorous characterizations of both MNF's physical properties (thermoelectric, solar absorption and thermal) and the device parameters. The transparent solar collector cell is currently being built by our partner laboratory (National Optical Institute, INO, Firenze, Italy) which will be assembled into a working device as shown in the figure at SPHYNX. The MNFs will be provided by our partner labs (INO and Sorbonne University). The internship has for its short-term goal to benchmark the prototype feasibility by determining the extractable magnitude of heat generation, thermal gradient and the power-output as a function of the irradiation power, cell geometry (including that of thermal insulator), nanoparticle concentration, applied magnetic field strength, fluid-flow patterns etc. Upon its successful completion, the internship will be converted into a PhD thesis research project investigating the underlying laws of physics behind the solar radiation absorption (heat) and the thermoelectric potential and power generation and other associated phenomena in magnetic nanofluids.

The internship is purely experimenta involvingl: thermoelectrical, thermal and optical measurements; implementation of automated data acquisition system and analysis of the resulting data obtained. Basic notions of thermodynamics, optics, fluid physics and engineering (device) physics, as well as hands-on knowledge of experimental device manipulation are needed. For motivated students, numerical simulations using commercial CFD software can also be envisaged but not mandatory.

**CONTACT**: Saco Nakamae 01 69 08 75 38, sawako.nakamae@cea.fr

**REFERENCES:**
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