PhD thesis proposal

Thermal radiation at nanoscale and implication for energy-harvesting devices *(French version of this Offer available upon request)*

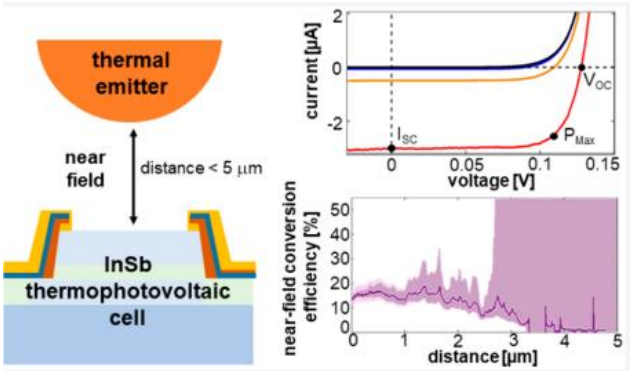
Advisor: P-Olivier Chapuis (Directeur de Recherche CNRS)
Location: Centre d'Energétique et de Thermique de Lyon (CETHIL), INSA Lyon, Villeurbanne (Lyon)

Context: Thermal radiation is one of the main heat transfer mechanism with heat conduction and heat convection, which exists even in absence of matter. It allows to harvest power, for instance from the sun by photovoltaic means. At usual macroscopic scale, one can neglect many electromagnetic features of the thermal-radiation carriers (photons) which are considered as particles, but this is not possible at nanoscale, where interference and sub-wavelength effects, including photon tunneling, enter into play. In particular, the heat exchanged between two bodies becomes huge when they are brought very close, in what is known as *near-field thermal radiation* exchange. Predicted 50 years ago, these effects have been demonstrated experimentally in the last ten years. Since important quantity of energy is exchanged, it is interesting to try to convert it in electricity, in energy-harvesting devices. Few years ago, we have demonstrated experimentally that devices with 15% efficiency can be used to harvest power close to 10 $kW.m^{-2}$ in *near-field thermophotovoltaic devices* (see Figure below) [1-2]. We therefore measure at the same time the energy exchange between hot and cold bodies and the power converted into electricity in a (cold) photovoltaic cell placed at the sample location. The work has been extended to room-temperature cells recently, at the cost of a lower output electric power. In parallel, we have developed an original setup to analyze the conversion of radiative power into electricity in what is known as *thermophotonics* [3]. In general, photovoltaics and all these related technologies can be seen as radiative heat engines.

PhD topic : The goal of the PhD thesis is to further develop the experimental setups and analyze thermal radiation and electroluminescence at nanoscale. Impact on the thermophotovoltaic conversion will be studied in detail, as well as other energy-harvesting techniques involving close proximity between hot source and cell.

The PhD fellowship will be granted after examination of the student's marks and selective defense in front of a jury of the Doctoral School. Therefore only brilliant students are encouraged to apply.

References



[1] (for French readers) Conversion thermophotovoltaïque : des principes aux applications, R. Vaillon, P.-O. Chapuis, Techniques de l'ingenieur, BE 8046 (2025). Open version
[2] Near-field thermophotovoltaic conversion with high electrical power density and efficiency above 14%, C. Lucchesi et al., Nano Letters 21, 4524 (2021) – see the CNRS press release
[3] Operating conditions and thermodynamic bounds of dual radiative heat engines, J. Legendre and P.-O. Chapuis, Physical Review Applied 23, 034023 (2025)

For more information, see website.

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