M2 Internship proposal, March-Septembre 2020

Thermal radiation at nanoscale and implication for energy-harvesting devices

(French version of this Offer available upon request)

Advisor: P-Olivier Chapuis (Chargé de Recherche CNRS)
Location: Centre d'Energétique et de Thermique de Lyon (CETHIL), INSA de 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. We have demonstrated experimentally that devices with 15% efficiency can be used to harvest power as high as 10 $kW.m^{-2}$ in *near-field thermophotovoltaic devices* (see Figures). We therefore measure in the same time the energy exchange between hot and cold bodies, and the power converted into electricity in a photovoltaic cell placed at the sample location.

The goal of the internship is to further develop the experiment and analyze thermal radiation at nanoscale with small tips used for thermal sensing. Impact on the thermophotovoltaic conversion will also be studied.

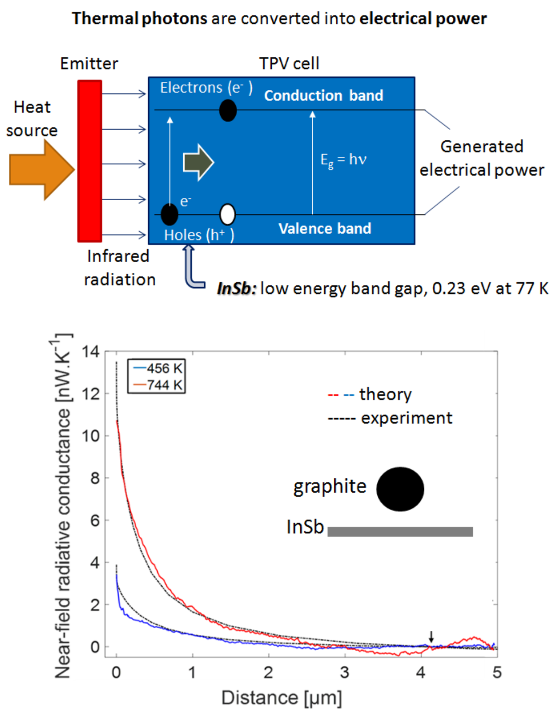

Figure: (a) Principle of a thermophotovoltaic energy-harvesting device (b) Large power increase when a hot body (here a graphite sphere) is brought close to a cold body (here an InSb plate).

References :

- *Harnessing near-field thermal photons with efficient photovoltaic conversion*, C. Lucchesi *et al.*, submitted to high-impact journal and already available online on ArXiV website
- *Indium antimonide photovoltaic cells for near-field thermophotovoltaics,* Dilek Cakiroglu, Jean-Philippe Perez, Axel Evirgen, Christophe Lucchesi, Pierre-Olivier Chapuis, Thierry Taliercio, Eric Tournié, Rodolphe Vaillon, Solar Energy Materials and Solar Cells 203, 110190 (2019)
- PhD student prize for C. Lucchesi at the French National Days on Solar Energy (JNES) in 2018. See News section in June 2018 on the CETHIL website.

For more information, see website.

Work to be performed:

- Understanding of the concept
- Use of the experimental setup
- Comparison with previous experimental data and analyze of different samples
- Final report

Dates: March-September 2020

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