INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

MANY-BODY NEAR-FIELD RADIATIVE HEAT TRANSFER: TOWARDS A TRANSISTOR FOR THERMAL PHOTONS, BEYOND PLANCK'S LAW

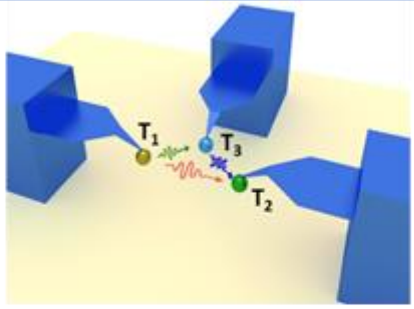

Figure 1: Sketch of of a near-field transistor for thermal photons.

Two solid bodies at different temperatures which are separated by vacuum exchange heat in the form of thermal photons. This exchange of energy is limited in the far field by Stefan-Boltzmann's law which is a direct consequence of Planck's law. On the other hand, in the near field (when the separation distance is smaller than the thermal wavelength) the flux can overcome this limit by several orders of magnitude due to tunneling of photons making this transfer prominent at nanoscale. Until recently, only the radiative exchange between two objects has been considered in this non-planckian near-field regime, first theoretically [1] and then experimentally [2-7]. As part of a third-year PhD, our group has developed an ultrasensitive probe able to capture the far-field to near-field transition of radiative heat transfer with unprecedented accuracy using a thermoresistive probe. This instrument was successfully used to measure the heat exchange in near and far field between a glass microsphere and a plane made of different materials (Si02, SiC, gold) [8].

In this project, we propose to develop the very first setup to experimentally investigate the near-field radiative heat exchanges by thermal photons in many-body systems. We will specifically address the case of micrometer-size objects for which the appropriate multipolar theoretical formalism will be developed by our collaborators (P. Ben-Abdallah and R. Messina, Labo. Charles Fabry – IOGS), to go beyond the dipole approximation suited for objects much smaller than the thermal radiation wavelength. **To this end, we will:**

- **Install additional probes in the experimental set-up developed by the previous PhD student** (from Master ICFP). Based on our expertise in nanosystems [9], a platform allowing the measurement of near-field radiative heat transfers between up to three or four micrometer sized bodies in high vacuum will be developed at Institut Langevin, in collaboration with the Laboratoire National de Métrologie et d'Essais (W. Poirier) which will provide its expertise in ultrasensitive measurements in quantum metrology [10].

- **Measure the near-field heat exchanges in simple many-body systems** by means of multiple interacting SThM probes supplemented by infrared thermal radiation studies. **A sketch of one of the configurations we are considering to study energy transfer between three spherical bodies in order to create the first near-field transistor for thermal photons is shown in Figure 1.** In parallel, a general formalism and/or numerical simulations will be developed to study the mutual radiative heat exchanges in many-body systems made of micrometer-size objects [11].

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[11] P. Ben-Abdallah, Phys. Rev. Lett. 123, 264301 (2019).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:
Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: YES Theoretical Physics: YES