Postdoc position in theoretical physics :
Casimir force in disordered metals

Location : "Quantum theory, Atoms & Fields" group, Laboratoire Kastler Brossel (LKB), Sorbonne Université, Campus Pierre et Marie Curie, Paris 05

Duration : 12 months minimum

Expected date of employment : September 2023, but the position will remain open until filled

Salary : 2889 euros per month before tax

Description :

When approached close to each other, two materials experience an attractive Casimir force due to quantum vacuum fluctuations [1]. A parent Casimir-Polder force also plays a role in the context of atom-surface interaction [2]. In the two cases, Casimir forces are usually the dominant ones at distances typically ranging from hundreds of nanometers to a few micrometers.

Many features of the Casimir interaction are correctly captured by an effective medium description where all the material heterogeneities are averaged out, so that optical properties of bulk matter is described by dielectric functions. This is the basis of the so-called scattering approach [3] which has been thoroughly investigated to interpret the results of the precise measurements of the Casimir force between two metallic plates ([4] and references therein).

The scattering approach also allows one to deal with more complex situations where the material reflects light in a non-specular manner, which affects the Casimir interaction potential [3]. For efficient reflectors such as metallic mirrors, the non-specular part of radiation is small but dissipation is known to be related to the disorder induced by heterogeneities in the system. As a consequence, the Casimir-Polder interaction between a metallic plate and an atom has been shown to have significant fluctuations around the prediction of effective medium theory [5] .

In the experiments between two metallic plates, the idealization of specular reflection by homogeneous media is also an approximation. A more general description of the Casimir potential has to be developed, combining techniques from both the theory of disordered systems [6, 7] and the scattering approach to Casimir forces [3]. The aim of the postdoc will be to develop such a description for a generic microscopic model of metals consisting of a large collection of heterogeneities ("scatterers") embedded in a homogeneous background. The main objective will be to understand how these heterogeneities affect the Casimir force between the two metallic plates. This description will involve both theoretical and numerical aspects.

Tasks : The hired postdoc will develop a theoretical description of the Casimir force in metals, by properly taking into account the random fluctuations of the conductivity associated with electron scattering from the metal's impurities. The Casimir interaction will be described within a scattering approach developed by the team, and electron scattering in the metal will be treated using either by microscopic, diagrammatic techniques or a random-matrix method. Numerical simulations will also be envisioned.

Skills : The candidate is required to have a sound knowledge in scattering or random-matrix theory, or in general in the theory of disordered systems. A solid expertise in numerical simulations (e.g, Python or C) is also required. Knowledge in the physics of the Casimir effect would be a plus, but is not mandatory. The hired postdoc will be highly dynamic, creative and motivated, both able to work independently and to regularly communicate with the team. The candidate must have a PhD degree in theoretical physics.

Application modalities : Candidates should send a detailed CV including reference names and a motivation letter to Nicolas Cherroret (cherroret@lkb.upmc.fr) or Serge Reynaud (serge.reynaud@lkb.upmc.fr).

[1] H. B. G. Casimir, Proc. K. Ned. Akad. Wet. **51**, 793 (1948).

[2] H. B. G. Casimir and D. Polder, Phys. Rev. **73**, 360 (1948).

[3] A. Lambrecht, P. A. Maia Neto, and S. Reynaud, New J. Phys. **8**, 243 (2006).

[4] S. Reynaud and A. Lambrecht, in *Quantum Optics and Nanophotonics* eds C. Fabre et al (Oxford Univ Press, 2017) p.407-455 (Les Houches Summer School, lecture notes available in the proceedings or in https ://arxiv.org/abs/1410.2746).

[5] N. Cherroret, P.-P. Crépin, R. Guérout, A. Lambrecht, and S. Reynaud EPL **117** 63001 (2017).

[6] A. Lagendijk and B. A. van Tiggelen, Phys. Rep. **270**, 143 (1996).

[7] M. C. W. van Rossum and Th. M. Nieuwenhuizen, Rev. Mod. Phys. **71**, 313 (1999).