CEA Saclay – Service de Physique de l'État Condensé (SPEC) (page web)
Laboratoire *SPHYNX* (page web)

PROPOSITION DE STAGE 2020-21

Vacuum friction on colliding atomic and subatomic structures

Key words: Quantum vacuum, Vacuum friction, QED, Dissipation, atomic and subatomic collisions
Internship duration: 4 to 6 months
Starting date: 15 February- 15 April 2021

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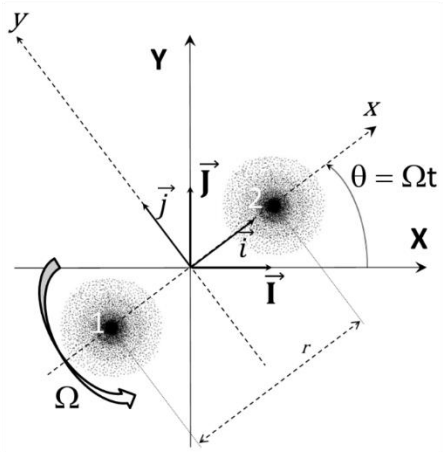
The quantum vacuum is populated with fluctuating, lowest energy states of particles and fields, a typically quantum, rather fascinating feature[1]. There are a few experimental demonstrations of consequences of vacuum fluctuations on static material structures, like the Lamb shift and the Casimir effect. When material systems evolve dynamically, a friction force is theoretically predicted, the so-called *Dynamic Casimir Effect*.
We have been investigating these phenomena as a possible cause of the second law of thermodynamics. Rotating pairs of atoms experience a torque from the zero-point electromagnetic field of the vacuum, calculated for identical[2] as well as for dissimilar atoms[3]. The material system exchanges angular momentum with the underlying vacuum.



This is reminiscent of the spin of the electron, which appears as intimately linked to the interaction of the particle with the vacuum fields: the zero-point electromagnetic field and Dirac field of electron-positron pairs. The goal of this internship is to calculate the dynamical effect of the Dirac sea on atomic collisions, by due consideration of the underlying dynamics of electrons and nuclei, protons to begin with.
A preliminary knowledge of Quantum Electrodynamics theory and calculations – at least using Feynman diagrams – is necessary. The internship will take place mainly at SPEC, bat. 772 in *l'Orme des Merisiers* site of CEA Saclay. Collaborations with other scientists in the Paris region are a possibility.

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[1] Milonni, P. W. *The quantum vacuum: an introduction to quantum electrodynamics* (Academic press, San Diego, 1994).
[2] Bercegol,H., Lehoucq,R., "Vacuum friction on a rotating pair of atoms", *Phys. Rev. Lett.***115**, 090402 (2015)
[3] De Izarra, A. « Effet du champ électromagnétique du vide sur les collisions atomiques », Univ. Tours, 2016.