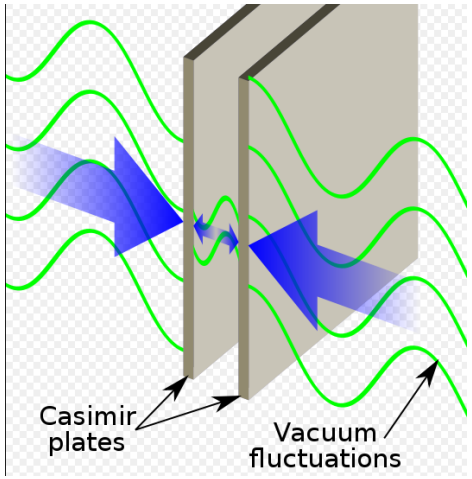
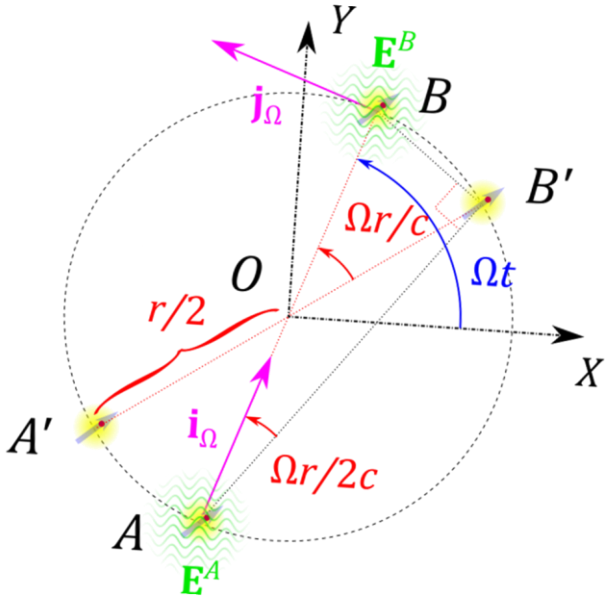
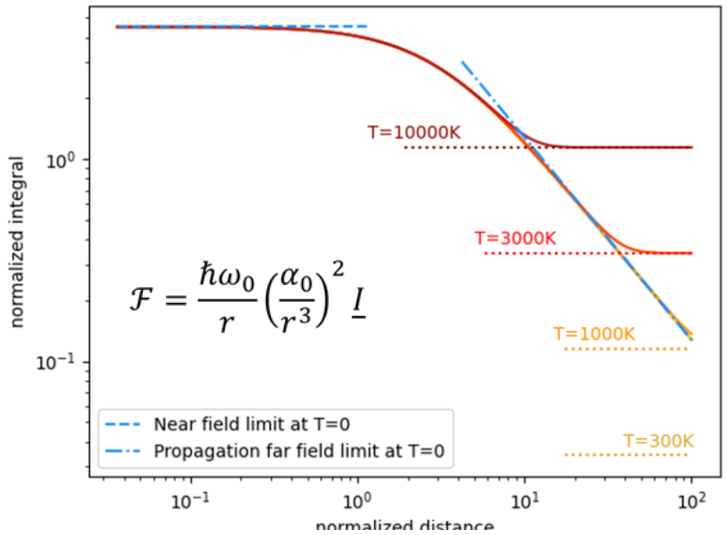
Internship proposal Spring 2025

COUPLED FRICTION EFFECTS OF DIRAC SEA AND ELECTROMAGNETIC VACUUM ON ATOMIC MOVEMENTS

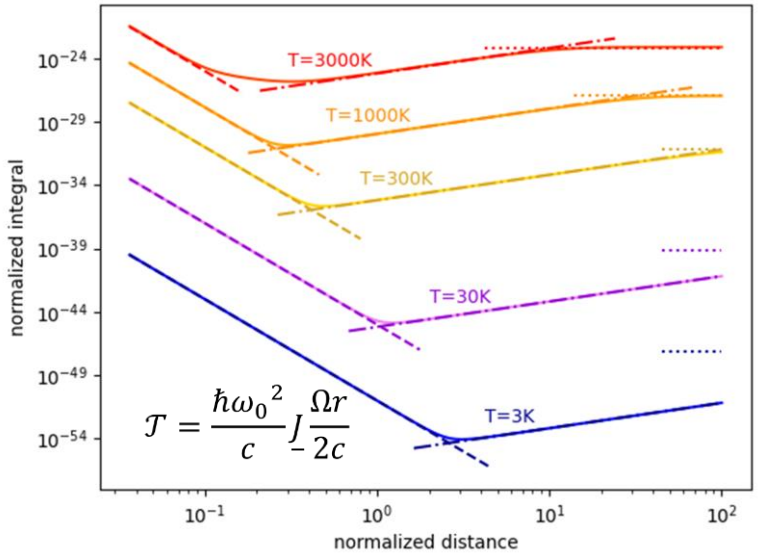


Source Wikipedia





*Normalized **attraction** $\underline{I}$ as a function of the normalized distance $\underline{r}$*



*Normalized **friction** $\underline{J}$ as a function of the normalized distance $\underline{r}$*

In our lab, we have been working on a semi classical model [1], which has recently provided a comprehensive solution to vacuum electromagnetic friction on rotating atoms [2] given at any distance and temperature. The same model is also shown to retrieve known results on interatomic conservative forces of quantum origin [3].

[1] Bercegol, H., Lehoucq, R., Vacuum friction on a rotating pair of atoms, Phys. Rev. Lett. 115, 090402 (2015).
[2] Vaz, M. & Bercegol H., Quantum friction on a rotating pair of atoms at all temperatures and all distances, in preparation
[3] Vaz, M. & Bercegol H., Complete range of interatomic attraction mediated by the quantum vacuum at all temperatures, in preparation

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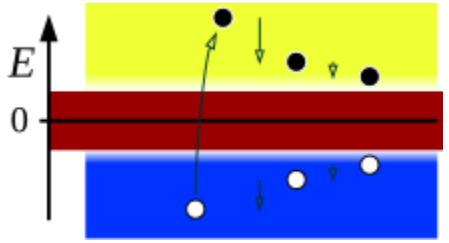
A fully quantum model should be developed for the rotating pair of atoms, in order to determine more rigorously these microscopic dissipative forces. An obvious, although tedious and uncertain path towards a complete quantum resolution would be to treat all interactions within a quantum electrodynamics formalism. **An alternative way** of research consists in upgrading the semi-classical model so that it includes such phenomena as vacuum polarization and interaction of electrons with virtual electron-positron pairs of the Dirac Sea [4]. The intern will develop this second possibility, in line with recent theoretical results [5].

The internship is expected to end up in a PhD position.



Source Wikipedia

- Up to now in our model, quantum fluctuations come through fluctuations of the electromagnetic (*E-M*) field (field correlations).
- Introduce intrinsic fluctuations of the electron (*zitterbewegung*)
  - ✓ Vacuum polarization
  - ✓ Electron-positron pair creation in electron's high field (Wigner)
- ✓ Combined effects of *E-M* and material fluctuations
  - ✓ Known in the case of static properties (anomalous electron gyromagnetic ratio, Lamb shift, etc.)
  - ✓ **What are their respective level in quantum friction ?**

[4] Milonni, P. W. (1994). The quantum vacuum: an introduction to quantum electrodynamics. Academic press.

[5] Tkatchenko, A., & Fedorov, D. V. (2023). Casimir self-interaction energy density of quantum electrodynamic fields. Physical Review Letters, 130(4), 041601.

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