Renormalizing Casimir Forces in Inhomogeneous Media

Ulf Leonhardt, Itay Griniasty*

Weizmann Institute of Science, Israel

***Email of Presenting Author: Itay.Griniasty@weizmann.ac.il**

Recent advances in computational and experimental techniques have initiated a renaissance in the physics of the Casimir effect [1] and related phenomena, ranging from manipulations of van der Waals forces in nanostructured materials to heat transfer across subwavelength distances. Casimir forces have also become technologically relevant for micromechanical devices where they are the cause of friction and stiction. Casimir forces originate from vacuum fluctuations that induce fluctuating dipoles in dielectric materials. These dipoles interact with each other, creating a macroscopic force between dielectric bodies: the Casimir force.

The theory on which the modern computational tools for Casimir forces in realistic materials are based, Lifshitz theory [2] has been put on firm foundations since 1961. Lifshitz theory gives accurate predictions of the Casimir forces between different objects. However, it fails in predicting the Casimir force inside an object if the object consists of smoothly varying inhomogeneous media: here the theory diverges [3,4]. As the Casimir effect is ultimately caused by vacuum fluctuations, the self-effect of those fluctuations need to be removed by a suitable regularizer. It turned out [3,4] that the original Lifshitz regularizer [2] that works perfectly well in the uniform space between different objects, fails in inhomogeneous materials. After a five-year quest of finding the right regularizer we believe to have discovered a procedure that works, at least in planar materials where we tested it. Our inspiration comes from transformation optics [5,6] and in particular from the interpretation of dielectric materials as effective spatial geometries. We use this geometrical perspective to identify the regularizer that makes Lifshitz theory convergent in inhomogeneous planar materials.

References

[1] A. W. Rodriguez, F. Capasso, and S. G. Johnson, Nat. Photon. 5, 211 (2011).
[2] I. E. Dzyaloshinskii, E. M. Lifshitz, and L. P. Pitaevskii, Adv. Phys. **10**, 165 (1961).
[3] T. G. Philbin, C. Xiong, and U. Leonhardt, Ann. Phys. **325**, 579 (2010).
[4] W. M. R. Simpson, S. A. R. Horsley, and U. Leonhardt, Phys. Rev. A **87**, 043806 (2013).
[5] H. Chen, C. T. Chan, and P. Sheng, Nat. Mat. **9**, 387 (2010).
[6] U. Leonhardt and T. G. Philbin, Geometry and light: the science of invisibility (Dover, 2010).