Energetics of quantum vacuum friction

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Quantum electromagnetic field fluctuations can induce a frictional force on a neutral but polarizable particle that is moving through free space filled with blackbody radiation. We explore the energetics of such a particle undergoing uniform motion. If the particle has purely real intrinsic polarizability, before being dressed by radiation, the only dissipative mechanism is through its interaction with the radiation field fluctuations. In this case, the particle is guaranteed to be in the nonequilibrium steady state (NESS), where it absorbs and emits energy at the same rate. However, if the particle is intrinsically dissipative, the corresponding intrinsic dipole fluctuations provide a further dissipative mechanism. In this case, the particle can be out of NESS, where it gains or loses net internal energy; indeed, it will be in NESS only if its temperature is equal to a special NESS temperature, which is a function of its velocity and the temperature of the blackbody radiation. In NESS, the frictional force is always negative definite, opposing the motion of the particle. However, out of NESS, the frictional force no longer has a definite sign in the rest frame of the blackbody radiation, though it remains negative definite in the rest frame of the particle. Numerical calculations of the NESS temperature and quantum vacuum friction are illustrated for models of a gold nanosphere.

[1] X. Guo, K. A. Milton, G. Kennedy, W. P. McNulty, N. Pourtolami, and Y. Li, Energetics of quantum vacuum friction: Field fluctuations, Phys. Rev. D 104, 116006 (2021).

[2] X. Guo, K. A. Milton, G. Kennedy, W. P. McNulty, N. Pourtolami, and Y. Li, Energetics of quantum vacuum friction. II: Dipole fluctuations and field fluctuations, Phys. Rev. D 106, 016008 (2022).