

# The Energetics of Quantum Vacuum Friction

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**Abstract:** We consider a neutral but polarizable particle moving through a quantum thermal vacuum. The balance of energy and momentum causes the particle to radiate and generates a frictional force on the particle. If the particle is like an atom with no intrinsic dissipation, the friction entirely originates in the fluctuations of the electromagnetic field. Alternatively, but equivalently, we can think of the particle as having dipole fluctuations, corresponding to a definite temperature different from that of the thermal background. The friction we are investigating is the relativistic generalization of the Einstein-Hopf effect. The frictional force and power may be interpreted through a Doppler distortion of the spectral density of the radiation. We find a number of interesting features depending on the velocity and the properties of the particle. The forces are small, but it may prove possible to observe such effects, either through deceleration or through measuring the temperature of the atom, for high velocities. The formalism we have developed may be readily applied to more complicated scenarios, such as a particle moving parallel to a dielectric or metal surface.

**Keywords:** quantum fluctuations; Casimir friction; radiation reaction

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