Fluctuation-electromagnetic phenomena under dynamic and thermal nonequilibrium conditions

Aleksandr Volokitin[1,2]

[1] *Samara State Technical University, Physical Department, 443100 Samara, Russia*
[2] *Peter Grünberg Institut, Forschungszentrum Jülich, D-52425, Germany*
alevolokitin@yandex.ru

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In recent years considerable attention has been paid to study fluctuation-electromagnetic phenomena for nonequilibrium systems [1]. This interest is due to the fact that in nonequilibrium systems it is possible to tune the fluctuation-electromagnetic phenomena that is extremely important for the design of nanoelectromechanical devices. It is necessary to distinguish several nonequilibrium situations: (1) Different parts of the system have different temperatures, but there is no relative motion between these parts. In such conditions, the Casimir-Lifshitz forces will be modified in comparison with their equilibrium values. Theoretically it was predicted and has been experimentally confirmed that the radiation heat flux between two bodies with different temperatures in the near-field region at many orders of magnitude greater than that determined by the classical Stefan- Boltzmann law. (2) Different parts of the system are in relative motion. For example, two macroscopic plates separated by a vacuum gap, slide against each other. Another example is an atom (or nanoparticle), moving or rotating over macroscopic plate. Relative motion between bodies affects the Casimir-Lifshitz forces and leads to dissipation and Casimir friction. Currently, Casimir friction attracts great attention due to the fact that it is one of the mechanisms of noncontact friction. Fluctuations of forces (and, consequently, friction) are important for ultrasensitive force registration. (3) There is no relative motion between parts of the system, but in some part of the system a DC current is induced or there is a narrow channel with a polar liquid flow. This leads to a change in strength of the Casimir force and radiation heat transfer, and the appearance of frictional drag force. Currently, the friction drag in low-dimensional structures (quantum wells, graphene) is actively studied both experimentally and theoretically due to of its importance in nanotechnology and deep theoretical problems. The friction drag effect is closely related to the Casimir friction. The results of experiments on the observation of frictional drag between quantum wells and graphene sheets, and the current-voltage dependence of graphene on the surface of the polar dielectric SiO2, were accurately described by us using theory of the Casimir friction [1]. In [2] we proposed to use effect of frictional drag for the mechanical detection of the Casimir friction force using an atomic force microscope. Recently it was shown that fluctuation-electromagnetic phenomena are strongly enhanced near singular resonance which exists due to multiple scattering of the electromagnetic waves in the condition of the anomalous Doppler effect [2, 3].

References

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