New Features of the Casimir Force for Magnetic Materials and Graphene

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Recent experimental results [1] have confirmed with certainty the previously made conclusion [2,3] that the Lifshitz theory of the van der Waals and Casimir force agrees with the measurement data only under a condition that the relaxation properties of conduction electrons in metals are not taken into account in computations. If the relaxation properties of conduction electrons are included in computations, the theoretical results turn out to be in contradiction with the measurement data of all precise experiments. In this talk, the thermodynamic properties of the Casimir interaction between magnetic materials [4] are discussed in connection with the measurement data of Ref. [1]. The hypothesis is analyzed that the commonly used phenomenological dielectric permittivities might be not equally applicable to describe the reflection properties of classical electromagnetic waves and quantum fluctuations in the state of thermodynamic equilibrium.

Special attention is devoted to the van der Waals and Casimir interaction for graphene whose polarization and dielectric tensors, as functions of the wave vector and complex frequency, were recently found [5] on the basis of thermal quantum field theory in the Matsubara formulation. This allowed investigation of special features of the thermal Casimir force in graphene systems [6] and established a link between the reflection properties of quantum fluctuations, on the one hand, and classical electromagnetic waves, on the other hand. Thus, in the case of graphene, we already have the resolution of the problem, which is not solved yet for conventional materials, such as metals, dielectrics and semiconductors. The experimental situation for the Casimir force in graphene systems and comparison between the measurement data and different theoretical approaches [7] are also elucidated on this basis.

References

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