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Universal experimental test for the role of free charge carriers in the thermal Casimir effect within a micrometer separation range

Bimonte G., Klimchitskaya G., Mostepanenko V.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2017 American Physical Society. We propose a universal experiment to measure the differential Casimir force between a Au-coated sphere and two halves of a structured plate covered with a P-doped Si overlayer. The concentration of free charge carriers in the overlayer is chosen slightly below the critical one, for which the phase transition from dielectric to metal occurs. One half of the structured plate is insulating, while the second half is made of gold. For the former we consider two structures, one consisting of bulk high-resistivity Si and the other of a layer of SiO2 followed by bulk high-resistivity Si. The differential Casimir force is computed within the Lifshitz theory using four approaches that have been proposed in the literature to account for the role of free charge carriers in metallic and dielectric materials interacting with quantum fluctuations. According to these approaches, Au at low frequencies is described by either the Drude or the plasma model, whereas the free charge carriers in dielectric materials at room temperature are either taken into account or disregarded. It is shown that the values of differential Casimir forces, computed in the micrometer separation range using these four approaches, are widely distinct from each other and can be easily discriminated experimentally. It is shown that for all approaches the thermal component of the differential Casimir force is sufficiently large for direct observation. The possible errors and uncertainties in the proposed experiment are estimated and its importance for the theory of quantum fluctuations is discussed.

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