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Measurement of the casimir force between 0.2 and 8 μm: Experimental procedures and comparison with theory

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Abstract

We present results on the determination of the differential Casimir force between an Au-coated sapphire sphere and the top and bottom of Au-coated deep silicon trenches performed by means of the micromechanical torsional oscillator in the range of separations from 0.2 to 8 μm. The random and systematic errors in the measured force signal are determined at the 95% confidence level and combined into the total experimental error. The role of surface roughness and edge effects is investigated and shown to be negligibly small. The distribution of patch potentials is characterized by Kelvin probe microscopy, yielding an estimate of the typical size of patches, the respective r.m.s. voltage and their impact on the measured force. A comparison between the experimental results and theory is performed with no fitting parameters. For this purpose, the Casimir force in the sphere-plate geometry is computed independently on the basis of first principles of quantum electrodynamics using the scattering theory and the gradient expansion. In doing so, the frequency-dependent dielectric permittivity of Au is found from the optical data extrapolated to zero frequency by means of the plasma and Drude models. It is shown that the measurement results exclude the Drude model extrapolation over the region of separations from 0.2 to 4.8 μm, whereas the alternative extrapolation by means of the plasma model is experimentally consistent over the entire measurement range. A discussion of the obtained results is provided.

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Keywords

Casimir force, Comparison between experiment and theory, Drude model, Gradient expansion, Micromechanical torsional oscillator, Plasma model, Precise measurements, Scattering theory

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