Comment on “Demonstration of the Casimir Force in the 0.6 to 6 μm Range”

In a recent Letter [1], Lamoreaux reports a measurement of the Casimir force for distances in the 0.6 to 6 μm range. The force has been measured between a flat and a spherical plate. Both plates are coated with a layer of Cu, covered with an additional 0.5 μm thick layer of Au. The author compares his experimental data to theoretical predictions [2] and reports an agreement at 5% between theory and experiment if a pure Cu surface is assumed. Since his theoretical evaluation [3] gives very different values for the Casimir force between Au surfaces and Cu surfaces, there results a net discrepancy between expected and experimentally observed values.

We have recently recalculated the Casimir force between metallic mirrors and obtained results differing significantly from [2,3], in particular, for Au mirrors. Details about the evaluation procedure, the interpolation and extrapolation of optical data, and the numerical integration techniques are given in [4]. Here, we restrict our attention to the Au/Cu problem underlined by Lamoreaux.

The upper graph in Fig. 1 shows the imaginary part of the dielectric constant $\varepsilon''(\omega)$ as a function of frequency ω for Au and Cu. All optical data are taken from [5]. At low frequencies they are extrapolated by a Drude model which is consistent with present theoretical knowledge of optical properties of metals and, at the same time, fits quite nicely higher frequency optical data. Since the optical response functions are very similar for Au and Cu, the Casimir forces evaluated from these functions are expected to be nearly equal.

In the experiment, the Casimir force is measured in the plane-sphere geometry. Theoretically it is evaluated by using the proximity force theorem. We do not discuss here the validity of this approximation but focus our attention on the effect of finite conductivity. We calculate the reduction factor η (notation of [2]; notation η_E in [4]) of the force in the plane-sphere geometry as the reduction factor of the energy evaluated in the plane-plane configuration. The frequency dependent reflection coefficients are derived from the dielectric constant, using causality relations, and η is then deduced through numerical integrations.

The lower graph in Fig. 1 shows η for Au and Cu with, as expected, equal values at better than 1% in the range of distances studied in the experiment. This contradicts theoretical values obtained by Lamoreaux. For Au at 0.6 μm our value $\eta = 0.87$ exceeds by 12% the value $\eta = 0.78$ given in [2], while at the same distance the values for Cu are compatible within 2%.

This result clears up the Au/Cu discrepancy pointed out in [2]. Besides this specific difficulty, more work is needed, on both the experimental and theoretical sides, to reach an accurate agreement between theoretical expectation and experimental measurements of Casimir force (see [4] and references therein).

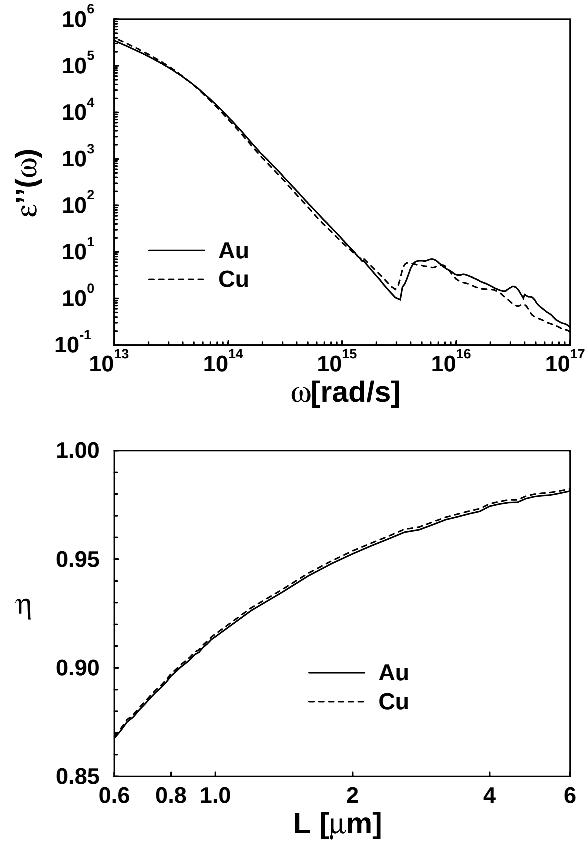

FIG. 1. The imaginary part of the dielectric constant as a function of frequency (upper graph) and the reduction of the Casimir energy between plane metallic reflectors with respect to plane perfect mirrors as a function of distance (lower graph) for Au (solid line) and Cu (dashed line).

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