Erratum: Demonstration of the Casimir Force in the 0.6 to 6 μm Range [Phys. Rev. Lett. 78, 5 (1997)]

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[S0031-9007(98)08011-9]

I report two errors relating to the theoretical interpretation of my measurement of the Casimir force in my Letter. The first error concerns the correction due to the finite conductivity of the Cu/Au films. Assuming a free electron gas model of a conductor with plasma wavelength λ_p, the correction to the Casimir force as a function of plate separation for the geometry used in the Letter is

$$\eta(a) = F_c'(a)/F_c(a) = \left(1 - \frac{2}{\pi}\frac{\lambda_p}{a}\right), \tag{1}$$

where $F_c(a)$ is the unmodified Casimir force as given by Eq. (2) of the Letter [note the sign error in Eq. (5)]. For the data reported in the Letter, the smallest separation between the plates is $a = 0.6$ μm; taking $\lambda_p \approx 500$ nm for Au or Cu gives $\eta \approx 0.47$. Such a large modification of amplitude and functional form is not supported by my data. Furthermore, Eq. (1) above is valid only when $(\lambda_p/a)^2 \ll 1$; my initial estimate for a more accurate correction was $\eta = 0.97$, in agreement with the experimental result. I have since performed a more accurate calculation and find $\eta(0.6\ \mu\text{m}) = 0.78$ for Au and 0.89 for Cu.

This numerical calculation is based on using the tabulated complex index of refraction of Au (or Cu) as a function of frequency to determine its complex permittivity, the imaginary part of which was then used with the Kramers-Kronig relationships to find the permittivity along the positive imaginary frequency axis, $\epsilon(i\omega)$; this was then inserted into the Lifshitz expression (see Sec. 90 of [1]) for the Casimir force, which is valid for a generalized complex permittivity [2]. The force as a function of plate separation was then integrated to give the potential energy $E(a)$ as required in Eq. (2) of the Letter to obtain the Casimir force between the flat and curved plates [3].

The correction to $F(a)$ given by this calculation varies much less rapidly with $a \approx \lambda_p$ than does Eq. (1) above, and the deviation from the uncorrected Casimir force is indistinguishable from an overall calibration error in my data or its interpretation. This error has been traced to the radius of curvature (R) measurement of the (assumed) spherical surface which enters directly into the theoretical interpretation through the proximity force theorem, $F(a) = 2\pi RE(a)$. The convex surface (Cu/Au coated lens) is aspheric, and R in the region where the Casimir force measurement was made is 12.5 ± 0.3 cm, to be compared to 11.3 ± 0.1 cm used in the Letter. The two errors described above affect only the

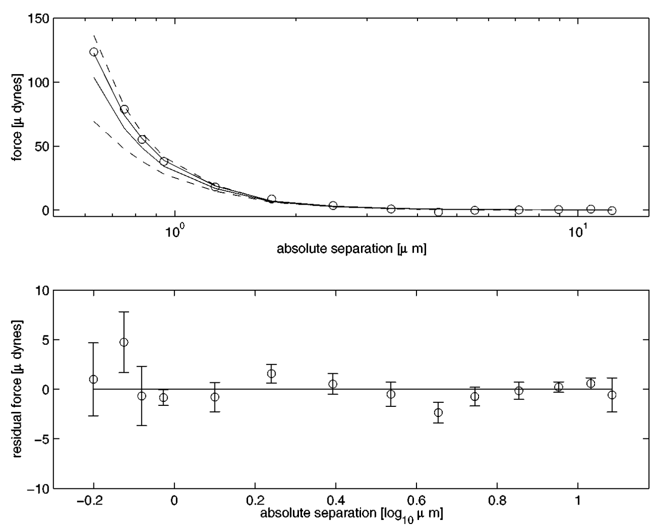

FIG. 1. Upper plot: Original data (circles) plotted with the more accurate calculations; upper solid curve is the calculation for Cu, the lower solid curve for Au. The upper dashed curve is the unmodified Casimir force (using $R = 12.5$ cm); the lower dashed curve shows the first order plasma frequency correction given by Eq. (1). Lower plot: Differences between the data and the Lifshitz theory for Cu.

0031-9007/98/81(24)/5475(2)\$15.00

theoretical curves shown in Fig. 4 of the Letter. The original data along with the new theoretical calculation is shown in Fig. 1 of this Erratum.

It can be seen that the more accurate finite conductivity calculation, assuming a pure Cu film, agrees with the experimental result at the level of 5%. Two implications are that the Au film had significantly diffused into the Cu layer, and/or the Au film thickness is less than $\approx 0.5\ \mu$m as stated in my Letter. Other corrections, e.g., the effects of finite temperature or surface roughness, are estimated to be significantly less than 10% and the data support no evidence for such. A more accurate analysis of the finite conductivity correction would require a direct measurement of the complex index of refraction of the Cu/Au films.

[1] L. D. Landau and E. M. Lifshitz, *Electrodynamics of Continuous Media* (Pergamon, Oxford, 1960).
[2] P. W. Milonni, *The Quantum Vacuum* (Academic Press, San Diego, 1994).
[3] A manuscript describing this calculation is in preparation.