Comment on "Contribution of Drifting Carriers to the Casimir-Lifshitz and Casimir-Polder Interactions with Semiconductor Materials"

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It has been shown that the application of the Drude model in the Lifshitz theory leads to problems [1]. The Letter [2] modifies the reflection coefficients by including screening effects. The modified coefficients were obtained through use of the Boltzmann transport equation which takes into account the drift and diffusion currents. Here we demonstrate that the inclusion of irreversible diffusion processes leads to thermodynamic and experimentally inconsistent results.

The authors apply their approach to only intrinsic semiconductors. This approach with the Debye-Hückel screening length R_{DH} is applicable, however, in all cases where charge carriers of density n are described by Maxwell-Boltzmann statistics (i.e., also for doped semiconductors with $n < n_{cr}$, some semimetals, and dielectrics with ionic conductivity). For the latter media n does not vanish as $T \to 0$, while the conductivity goes to zero due to the vanishing mobility. Then, repeating the calculations of [3] using the approach [2], one finds a nonzero value of the entropy at $T = 0$, which depends on the separation, i.e., a violation of Nernst's theorem.

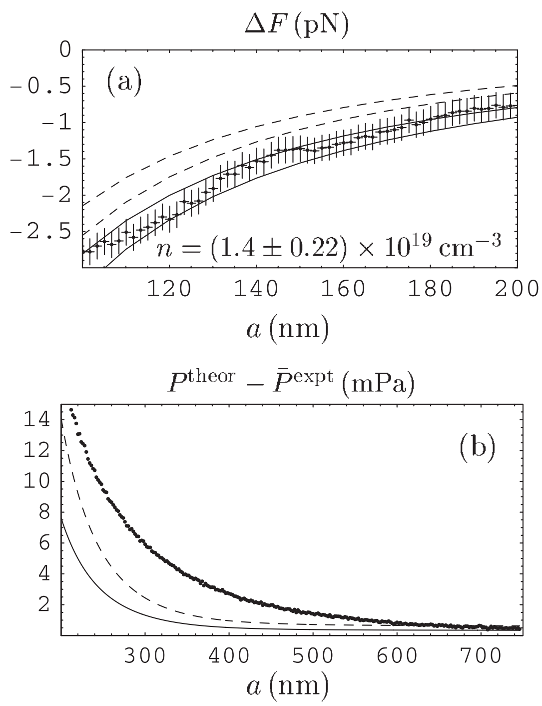

FIG. 1. (a) The measured force differences shown as crosses versus separation a. The two theoretical bands lie between the solid and dashed lines. (b) The pressure differences are shown as dots; the solid and dashed lines indicate confidence intervals at 95% and 99.9%, respectively.

In Fig. 1(a) we present the mean measured differences of the Casimir force between an Au sphere and a Si plate in the presence and in the absence of light on it [4]. Computations are done using [2] and with Si conductivity neglected in the dark phase [4] (the bands between the dashed and solid lines, respectively, caused by the uncertainty in n). Both the experimental and theoretical errors are determined at a 70% confidence level. At this confidence the approach of [2] is experimentally excluded.

The modified reflection coefficients of [2] are also applicable to metallic plates if R_{DH} is replaced with the Thomas-Fermi screening length. In this case, the approach [2] is similar to the Drude model approach and leads to the same negative entropy at $T = 0$ for perfect crystal lattices [5]. In Fig. 1(b) we plot as dots the differences of the theoretical pressures [2] and the experimental mean pressures [6] between two Au plates. It is seen that the approach [2] is excluded at a 99.9% confidence level. The reason for its failure is the inclusion of irreversible processes into the Lifshitz formula derived under the condition of thermal equilibrium. Drift and diffusion currents are initiated by only external electric fields. They lead to unidirectional fluxes of heat from the system to the heat bath, whereas fluctuating fields lead to equal and mutual exchange of heat.

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