Supporting Information for

Nanolevitation Phenomena in Real Plane-Parallel Systems due to the Balance between Casimir and Gravity Forces

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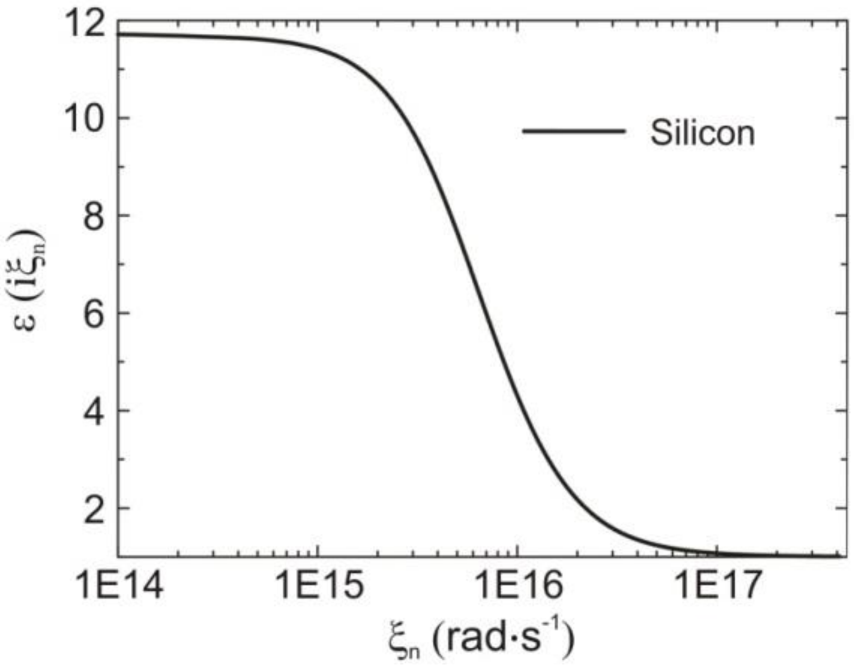

Figure S1: Dielectric permittivity evaluated at Matsubara frequency, $\varepsilon(i\xi_n)$, of Si (with a doping level $1.1 \cdot 10^{15}$ cm^{-3} and resistivity 0.077 $(\Omega \cdot cm)^{-1}$) for an extended frequency range.

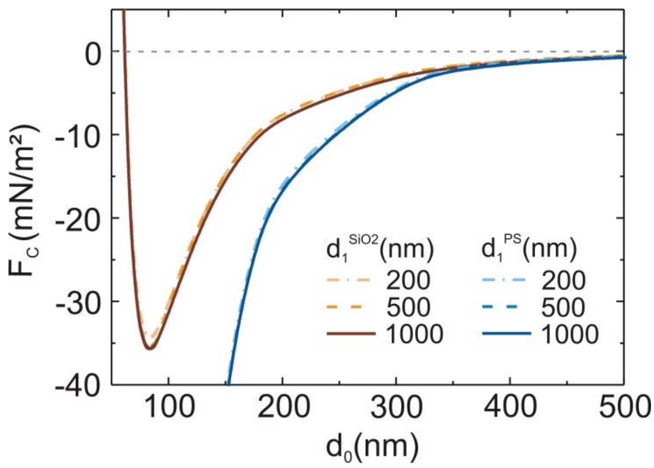

Figure S2: Casimir force (at room temperature) acting on thin films of silica (SiO_2) and polystyrene (PS) immersed in glycerol over a silicon (Si) substrate, as a function of the separation distance, d_0. Film thicknesses of $d_1 = 200, 500, 1000$ nm are considered.

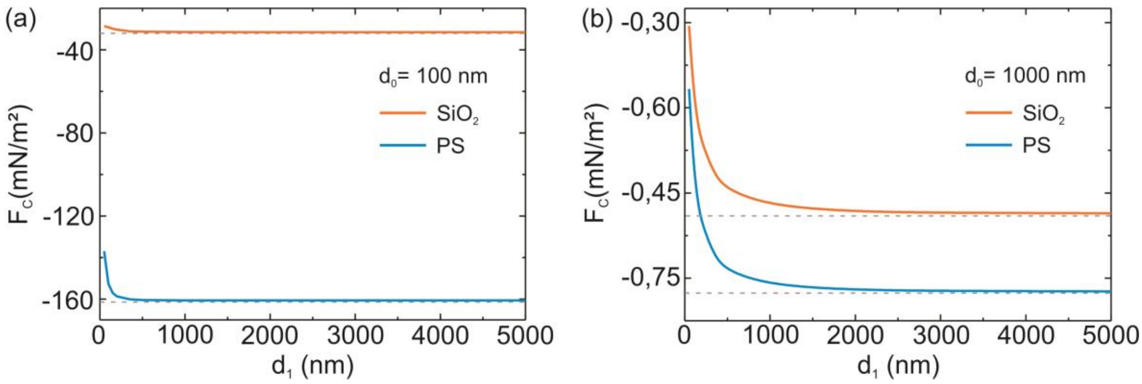

Figure S3: Casimir force as a function of thickness for a single slab of SiO_2 (orange) or PS (blue) inmersed in glycerol over a silicon substrate at (a) $d_0 = 100$ nm, and (b) $d_0 = 1000$ nm. The interaction for thick enough slabs tends to the limiting case of two semi-infinite media (displayed with dashed grey lines) as d_1 increases.

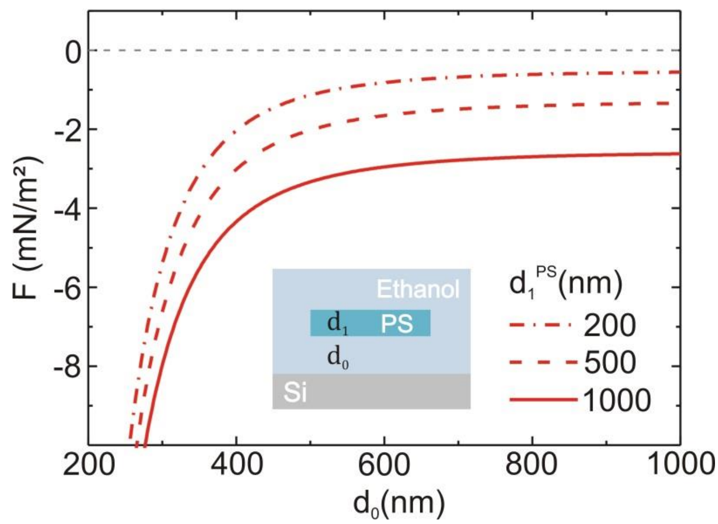

Figure S4: Total force (at room temperature) acting on thin films of PS immersed in ethanol over a Si substrate, as a function of the separation distance, d_0. Film thicknesses of $d_1 = 200, 500, 1000$ nm are considered. $F(d_0, T) = 0$ is marked with light grey lines. In the calculations we consider, $\rho_{PS} = 1.05$ g/cm³, $\rho_{ethanol} = 0.79$ g/cm³, and the permittivity reported in Ref.[1-3], Ref.[4,5] and Ref.[6] for PS, Si, and ethanol, respectively. In all cases, an attractive (negative) force is displayed, and no equilibrium distances are found.

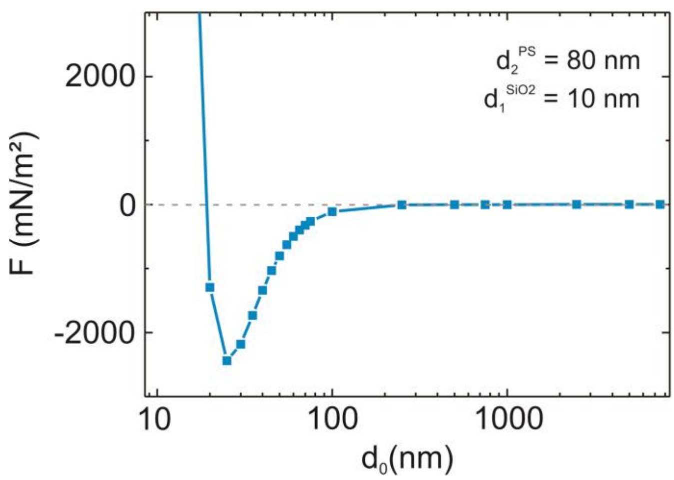

Figure S5: Total force (at room temperature) acting on a bilayer film with a bottom layer made of PS and a thin film of SiO2 on top immersed in glycerol over a silicon substrate. The thickness of the SiO2 ($d_2^{SiO_2}$) is fixed to 10 nm and the thickness of the PS (d_1^{PS}) to 80 nm. The figure shows how the sign of the total force changes with the separation distance (d_0). In this system we find two values of d_{eq}, ($d_{eq}^{stable}\sim$ 20 nm and $d_{eq}^{unstable}\sim$ 1600 nm) where the lower corresponds to a stable equilibrium position (F changes from positive to negative values) and the other one to an unstable equilibrium distance (F changes from negative to positive values).

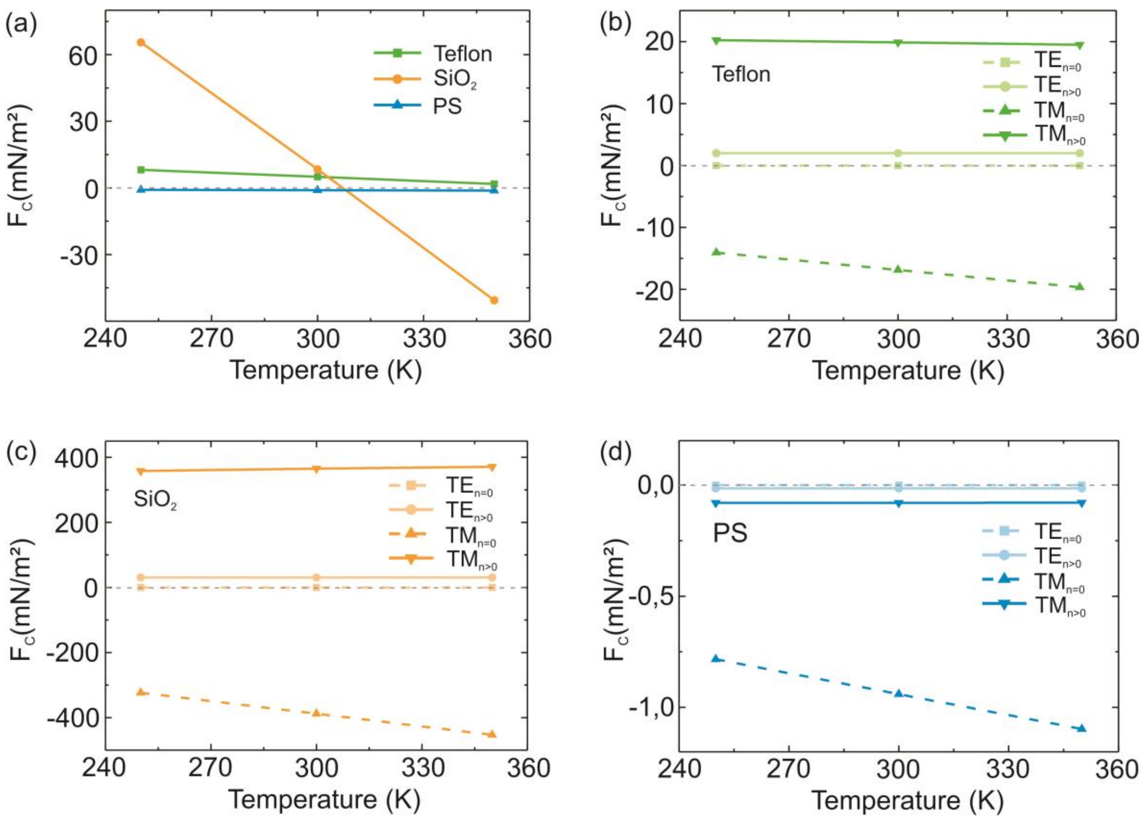

Figure S6: (a) Casimir force as a function of temperature for single layers with thickness fixed to 500 nm immersed in glycerol over a silicon substrate for Teflon, SiO_2 and PS. The gap distance is chosen to be, in each case, that of equilibrium at 300 K in Figure 4 in the main manuscript: $d_0 = 175$ nm for teflon (green), $d_0 = 60$ nm for SiO_2 (orange), and $d_0 = 450$ nm for PS (blue). Casimir force contributions of the TE and TM polarizations at $n = 0$ and $n > 0$ for (b) teflon, (c) SiO_2 and (d) PS.

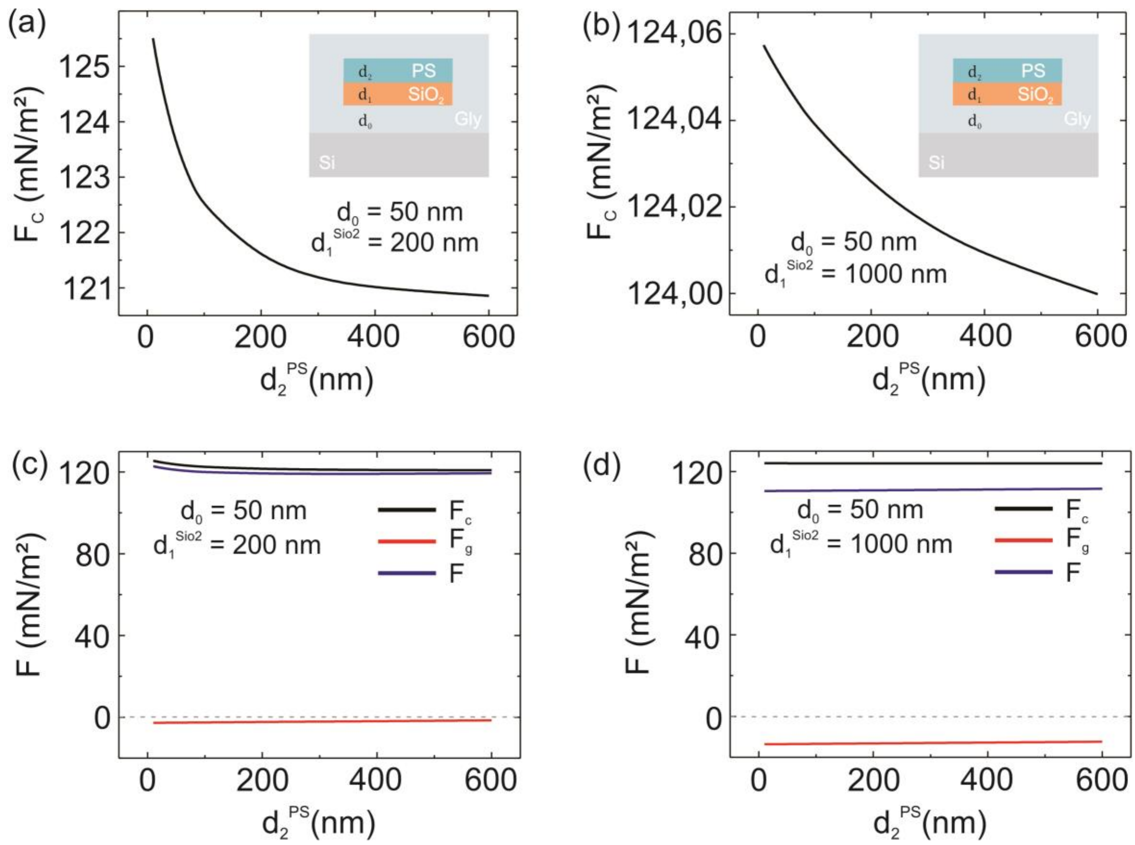

Figure S7: For a bilayer system with a lower SiO_2 layer, and a PS layer on top, immersed in glycerol over a Si substrate a distance $d_0 = 50$ nm, Casimir force as a function of PS thickness for (a) $d_1 = 200$ nm and (b) $d_1 = 1000$ nm. Panels (c) and (d) display the total force, Casimir force and gravity force for the same systems as in panels (a) and (c), respectively.

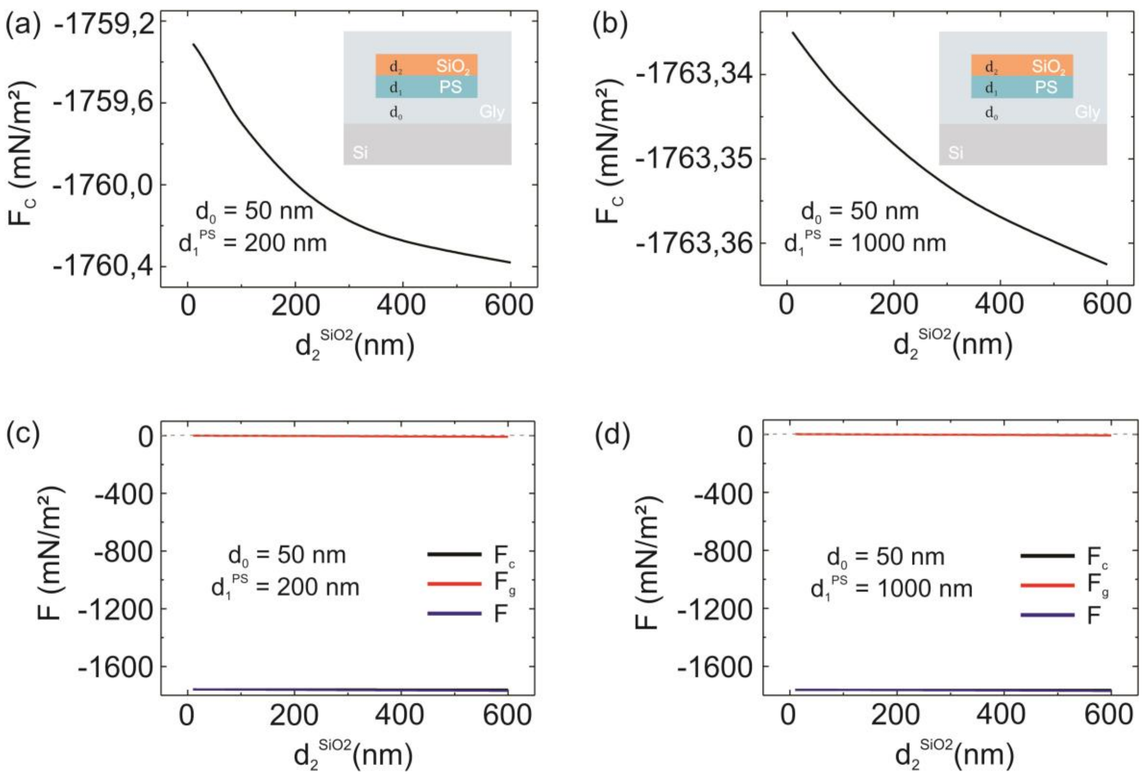

Figure S8: For a bilayer system with a lower PS layer, and a SiO_2 layer on top, immersed in glycerol over a Si substrate a distance $d_0 = 50$ nm, Casimir force as a function of PS thickness for (a) $d_1 = 200$ nm and (b) $d_1 = 1000$ nm. Panels (c) and (d) display the total force, Casimir force and gravity force for the same systems as in panels (a) and (c), respectively.

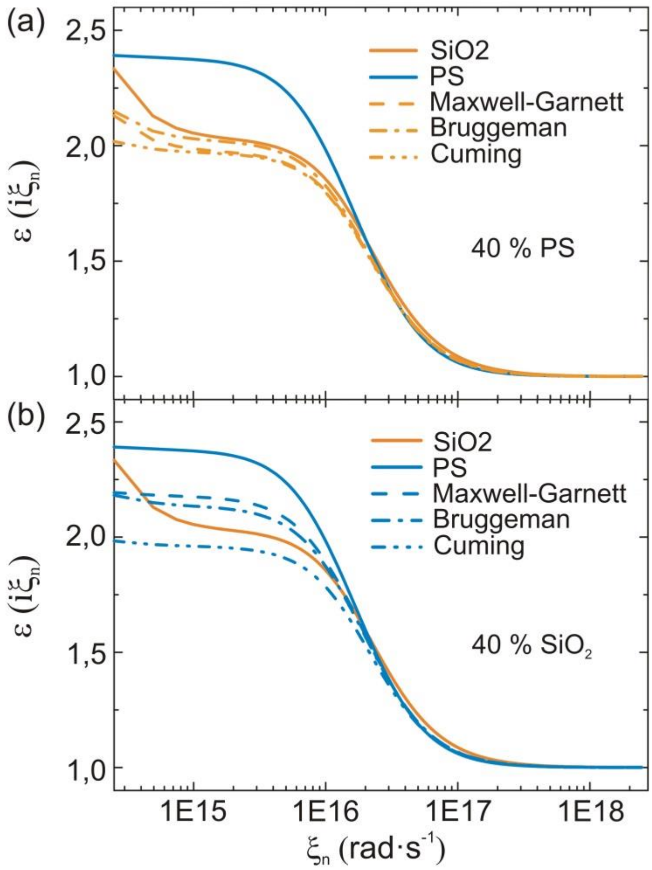

Figure S9: Permittivity evaluated at Matsubara frequencies, $\varepsilon_{eff}(i\xi_n)$, according to Maxwell-Garnett, Brugeman, and Cuming models, for $f = 0.4$ in (a) a SiO_2 matrix with PS inclusions, and (b) the complementary system, i.e., a PS matrix with SiO2 inclusions. For comparison, $\varepsilon(i\xi_n)$ of SiO_2 and PS are also displayed.

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[1] Strom, U.; Hendrickson, J.R.; Wagner, Ri.; Taylor, P.C.; Disorder-induced far infrared absorption in amorphous materials. Solid State Commun. **1974**, 15, 1871-1875.
[2] Folks, W. R.; Pandey, S. K.; Pribil, G.; Slafer, D.; Manning, M.; Boreman, G. Reflective infrared ellipsometry of plastic films, Int. J. Infrared Milli. Waves **2006**, 27, 1553–1571.
[3] Inagaki; T.: Arakawa, E. T.; Hamm, R. N.; Williams. M. W. Optical properties of polystyrene from the near-infrared to the x-ray region and convergence of optical sum rules. Phys. Rev. B **1977**, 15, 6.
[4] Duraffourg, L. Andreucci, P. Casimir force between doped silicon slabs. Phys. Lett. A **2006**, 359, 406–411.
[5] Edwards D. F., in: E. D. Palik (Ed.), Handbook of Optical Constant of Solid, vol. 1, second ed., Academic Press, **1985**, p. 547.
[6] van Zwol, P. J.; Palasantzas, G. Repulsive Casimir forces between solid materials with high-refractive-index intervening liquids. Phys. Rev. A **2010**, 81, 062502.