

On the environmental influence on the force between two metallic plates of a gripper immersed in a nonpolar fluid: the role of the temperature and the chemical potential

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Abstract

The total force $F_{tot}(T, \mu, L)$ between the plates of a gripper, which working arms are separated at a distance L from each other, depends on the environmental conditions in which it is working characterized, among the others, via the temperature T and the chemical potential μ of the fluid in which it is immersed. In the current study we present a model of a gripper immersed in a nonpolar fluid, which can be liquid, or gas, and calculate the dependence of the total force on the temperature, the chemical potential, and the distance L , using a suitable mathematical program that solves a set of (L/a) coupled nonlinear equations for the order parameter profile of the fluid between the plates of the gripper, where a is the characteristic distance between the molecules of the fluid. In our approach we take into account the direct substrate-substrate van der Waals interaction $\sim J^s$, the van der Waals interactions between the molecules of the fluid with the other molecules of the fluid $\sim J^l$, as well as with the constituent elements of the substrate, which is proportional to $J^{l,s}$, and the interaction between the plates generated by the fluctuations of the density of the fluid (i.e., the Casimir force). We suppose that both arms of the gripper are made out of the same material which strongly prefers the liquid phase of the fluid. We conclude that $F_{tot}(T, \mu, L)$ strongly depends on the contrast, at given fixed T and μ , between the physical properties of the fluid and the material of the arms of the gripper and is proportional to $J^l [\rho_l - \rho_s J^{l,s} / J^l]^2$, where $\rho_l(T, \mu)$ is the number density of the fluid, and ρ_s is the number density of the substrate. Our approach can be applied to any nonpolar fluid. We present, as example, results for ^4He and ^3He considering the working arms of the gripper being made of Au.

Keywords: grippers, thin fluid films, nonpolar fluids, van der Waals forces, Casimir effect
