THERMAL EFFECTS OF THE SURFACE-ATOM INTERACTION: THEORY AND RECENT EXPERIMENTAL RESULTS WITH ULTRA-COLD GASES

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The Casimir-Polder force characterizes the surface-atom force originating from the fluctuations of the electromagnetic field. Such a force and its cousin, the van der Waals force, are not only fascinating scientifically but also important technologically because of their relevance for instance to atomic force microscopy and to MEMS.

Our work [1] focused on the theoretical study of the temperature dependence of the force both at equilibrium and out of thermal equilibrium. In particular, when the temperature of the surface is different from the temperature of free space, the force is predicted to decay more slowly at large distances and to exhibit a stronger dependence on the temperature.

By positioning a Rb-87 Bose-Einstein condensate a few microns from a dielectric surface and resonantly exciting it into a mechanical dipole oscillation [2], the JILA team has recently observed changes in the collective oscillation frequency that result from the spatial variations in the force [3]. Clear evidence of non-equilibrium effects have been found [4]. Measurements agree with the theoretical predictions, marking the first conclusive demonstration of the temperature dependence of the Casimir-Polder force, indeed of any dispersion interaction.. Future perspectives for accurate measurements of the surface-atom force using Bloch oscillations [5] will be also discussed.

We will also show a recent investigation [6] of the force acting between two parallel plates held at different temperatures. The force reproduces, as limiting cases, the well known Casimir-Lifshitz surface-surface force at thermal equilibrium and the surface-atom force out of thermal equilibrium derived in [1]. The asymptotic behaviour of the force at large distances is explicitly discussed. In particular when one of the two bodies is a rarefied gas the force is not additive, being proportional to the square root of the density. Nontrivial cross-over regions at large distances are also identified

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