Casimir interaction in colloidal and biophysical systems

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Fluctuations of the electromagnetic field are at the origin of the Casimir interaction between objects at distances in the submicrometer regime up to a few micrometers. While the Casimir interaction is often thought of as a quantum effect, the high-temperature limit still leads to a finite force which is then of entropic origin. Experiments are mostly carried out with metallic objects in a sphere-plane or sphere-sphere geometry. For these geometries and Drude-type metals, analytical high-temperature results are available, including the case of two spheres of different radii [1]. However, the high-temperature limit is only attained for distances larger than typically 7.6 μm where the Casimir force is rather weak.

Recently, optical tweezers have been employed to measure the Casimir force between two dielectric spheres in an electrolyte [2]. There, thermal fluctuations are expected to be dominant at distances as small as 100 nm. The Casimir interaction then corresponds to a significant fraction of the thermal energy at room temperature so that the thermal Casimir force becomes relevant in colloidal as well as biophysical systems [3, 4]. Due to the non-zero dc conductivity of the electrolyte, the thermal Casimir interaction is universal, a property shared with the case of Drude-type spheres mentioned above. For dielectric spheres, new numerical calculations were performed in the plane-wave basis to cover the whole range of distances between the objects involved [5]. Interestingly, a simple interpolation formula bridging between small and large distances was found which is accurate enough for practical applications.

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