Casimir Force Reversal Using Metamaterials

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We investigate conditions for Casimir Force (CF) reversal between parallel metamaterial plates separated by air or vacuum at ambient temperatures. Practically, CF can lead to stiction effect in nanoscale devices, degradation and decreased performance. While material realizations of repulsive CF has been proposed for high dielectric host materials, so far no system has shown CF reversal with air as intermediate medium. Since, air is the natural medium for almost all devices; it is desirable to seek CF reversal under such ambient conditions. Here, we propose a two plate design based on artificial electromagnetic materials known as metamaterials. A parametric space study has been performed in terms of the plate's dielectric and magnetic plasma frequencies, plate separation distance and ambient temperature. The parametric domain for achieving CF reversal is identified. For non-dispersive systems, a universal CF reversal condition is derived showing good agreement with the numerical results. For dispersive systems, we consider a particular two plate configuration which mimics the ambient environment for micro electromechanical devices. This configuration allows a simple analytical treatment that accurately describes the large and short distance asymptotics of CF and allows extraction of important parameters such as lower and upper cutoff gap distances that define the repulsive force window. Finally, if successfully implemented the proposed system design could potentially result in frictionless bio-fluid transport devices, quantum levitation and coating for ultra-clean room environment.