Casimir Forces and Heat Transfer between Heterostructures & Influence of External Magnetic Fields

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Fluctuation induced interactions such as the Casimir force and the near field radiative heat transfer have two main contributions propagating and evanescent waves. In both cases the interaction depends on the local dielectric function of the materials. For an otherwise isotropic material, the application of an external magnetic field induces an anisotropy. This is particularly true in doped semi-conductors where surface plasmons become magneto plasmons with the application of an external magnetic field.

Hetero structures provide suitable systems to study the role of magneto plasmons in fluctuation induced interactions, since their dispersion relation can be tuned by the geometry of the system and the magnitude of the applied magnetic field. The two hetero structures we consider are Al(x)Ga(1-x)As and Cd(x)Mn(1-x)Te, the former being of interest in solar cell technology.

In this work we calculate the Casimir force between hetero structures at the same temperature and the near field heat transfer when there is a temperature difference between the structures in the presence of an external magnetic field. In particular we choose the Voigt configuration where the magnetic field is parallel to the planes of the hetero structure. This configuration has practical advantages, for example the dispersion relation of the magneto plasmons is described by the Voigt dielectric function and avoids mode conversion.

As a function of the periodicity of the hetero structures, the concentration (x) and the amplitude of the applied magnetic field, we show the modulation of the Casimir force, in particular how its magnitude can be changed and tune to a particular value by a sensible choice of the above parameters. In the case of near field heat transfer, magneto plasmons shifts the plasmonic response to the infrared, favoring near field heat transfer. Furthermore, for a large enough periodic heterostructure the frequency of the band gaps can be additionally use to enhance or inhibit the heat transfer.

Finally, the extension of our results to photonic hyper crystals will be discussed.