COLLECTIVE ELECTRONIC EXCITATIONS IN THIN FILMS

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Collective electronic excitations at metal surfaces are well known to play a key role in numerous phenomena, ranging from physics and material science to biology and medicine. From the fifties it is known [1] that at the planar vacuum/metal boundary a mode, called surface plasmon, emerges with frequency $\omega_{sp} = \omega_p / \sqrt{2}$, where ω_p is the bulk plasmon frequency. This relation between the bulk and surface plasmon frequencies is a manifestation of the fact that in a long-wavelength limit both quantities are entirely determined by the bulk dielectric function properties. In particular, the surface plasmon properties at small momentum transfers can be studied on base of a surface response function g [2] related to bulk dielectric function ε as $g = (\varepsilon - 1)/(\varepsilon + 1)$. In thin films, due to the presence of two surfaces, the interaction of corresponding surface plasmons produces its hybridization [1]. As a result, the dispersion of two symmetric and antisymmetric surface modes of a film with thickness L is expressed as $\omega_{sp}^{\pm} = \omega_{sp}\sqrt{1 \pm e^{Lq}}$, where q is an in-plane momentum.

In real metallic systems the dielectric function is often very different from the predictions of the free-electron-gas mode. In particular, recently it was demonstrated that indeed in many materials, like normal [3], charge-density-wave [4,5] and superconducting [6-10] metals and intercalated graphite [11], additionally to the conventional bulk plasmon, there exists a number of other bulk collective modes characterized by significantly lower frequencies. In this contribution we analyze which impact the presence of such low-energy modes in the bulk may produce on collective electronic excitations in thin films.

Keywords: Thin films; Surface plasmon; Dielectric function

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