Field-induced magnetization of the free-electron gas in thin films

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The free-electron model in thin films is considered when the external magnetic field is applied. The thin film is understood here as a 1-dimensional quantum well having the finite width (the film thickness) and the infinite depth. For such a model the Fermi surface calculations have been presented in [1]. In the present paper the formulas for the paramagnetic electronic susceptibility are given in the approximation corresponding to the linear response of the system to the field. Paramagnetic electronic susceptibility in q-space has then a form of the sum of the generalized Lindhard functions, taking into account in the summation all possible standing wave modes excited in the thin film. The ordinary Lindhard function is obtained when the ideal 2-dimensional system is considered [2], *i.e.* for the thin film with zero thickness.

In a particular case, by applying the spatially uniform external magnetic field (with q=0), the Pauli paramagnetic susceptibility of the thin film is obtained. It is shown that when the thickness of the film tends to infinity, the well-known Pauli paramagnetic susceptibility of the bulk material [3] is recovered as a limiting case. The formula for the field-induced magnetization of the electron gas in the thin film, normalized to the corresponding magnetization of the electron gas in the bulk material, is derived.

Some selected numerical results for the films with the thickness of several atomic planes and with the typical electronic density corresponding to copper are presented. In particular, it is shown that the magnetization is an oscillating, saw-toothed function of the film thickness, and its shape precisely corresponds to the density of states at the Fermi level [1]. Such oscillating behaviour of the electronic magnetization (and thus the Pauli paramagnetic susceptibility) is a thin film phenomenon. It can be easily explained by the discretization of the Fermi surface in thin films and resulting dependence of the Fermi wavevector on the film thickness [1].

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[1] T. Balcerzak, Thin Solid Films **500** (2006) 341.
[2] M. T. Béal-Monod, Phys. Rev. B **36** (1987) 8835.
[3] K. Yosida, " Theory of Magnetism ", Springer-Verlag, Berlin, (1998).

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