Comment on "Guiding-Center-Drift Resonance in a Periodically Modulated Two-Dimensional Electron Gas"

In a recent Letter, Beenakker[1] addressed (within a semiclassical approach based on the relaxation-time approximation) the novel magnetoresistance oscillations discovered by Weiss *et al.*[2] in 2D electron systems with a periodic modulation in one direction (say, the x direction). He was able to explain the pronounced novel oscillations of ρ_{xx}, but he emphasized that, as an exact consequence of the Boltzmann equation and for arbitrary strength of the modulation potential, the other components of ρ remain those of the usual Drude theory, without any oscillations. Beenakker concludes that the novel oscillations of ρ_{xx} are classical in nature, whereas the (weaker) antiphase oscillations in ρ_{yy}, which are also clearly seen in experiment, are not understood.

Beenakker's calculation essentially reproduces and confirms the results[3] obtained within a quantum-mechanical approach, evaluating Kubo's formula numerically under the *ad hoc* assumption of a *constant transport scattering time* τ. However, within a consistent quantum-mechanical theory, the assumption of a constant τ has no justification, and transport coefficients will exhibit quantum oscillations similar to those of the density of states (DOS), as is well known from the usual Shubnikov–de Haas oscillations.

The aim of this Comment is to emphasize that, contrary to the classical picture, a quantum theory, which treats the collision-broadening effects on the modulation-broadened Landau bands[3] and the current relaxation in a consistent manner, is able to explain all the observed oscillatory effects as resulting from the same origin, the oscillatory dependence of the bandwidth on the band index,[3] and that no additional mechanism has to be invoked to explain the oscillatory behavior of ρ_{yy}.

This statement is based on the extension to transport theory of our calculation[4] of modulation effects on the DOS within the self-consistent Born approximation, which explained the magnetocapacitance measurements on modulated samples very well.[4] Numerical results, which compare favorably with the experiments,[2] are shown in Fig. 1. It turns out that the oscillations of ρ_{yy} are in phase with the oscillations of the DOS (although the amplitudes are very different) and become maximum when the Landau bands at the Fermi level become flat.[3] The vanishing of the additional modulation-induced Hall- drift contribution to ρ_{xx} in this situation makes ρ_{xx} minimum and, thus, leads to the observed phase difference.

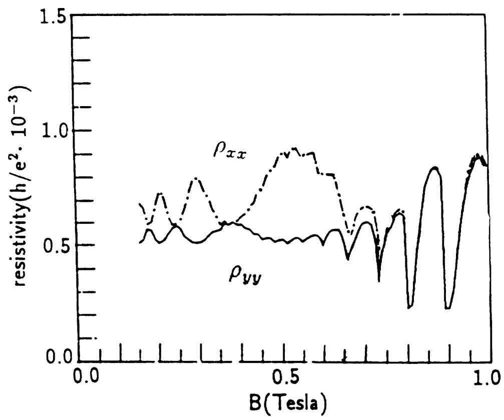

FIG. 1. Calculated resistivities in units of $10^{-3}h/e^2 = 25.81\ \Omega$ vs magnetic field for a 2D electron gas with density $n_s = 3.4\times10^{11}$ cm^{-2} and a modulation potential $V(x) = V_0 \times\cos(2\pi x/a)$, with $a = 294$ nm and $V_0 = 0.25$ meV at $T = 4.2$ K. The damping constant Γ is adjusted to a mobility of 1.34×10^6 cm^2/V s at $B = 0$.

Note added.—A detailed discussion of our theory and its implications has been submitted for publication. A recent calculation by Vasilopoulos and Peeters[5] neglects collision-broadening effects and obtains oscillations of ρ_{yy} with a much (more than an order of magnitude) smaller amplitude.

Rolf R. Gerhardts and Chao Zhang
Max-Planck-Institut für Festkörperforschung
D-7000 Stuttgart 80
Federal Republic of Germany

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