Sharply increasing effective mass and possible spontaneous spin polarization in a dilute two-dimensional electron system

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At sufficiently low electron densities, an ideal two-dimensional (2D) electron system becomes strongly correlated, because the kinetic energy is overpowered by energy of electron-electron interactions. There are several possible candidates for the ground state of the system, for example, (i) a Wigner crystal characterized by spatial and spin ordering [1], (ii) a ferromagnetic Fermi liquid with spontaneous spin ordering [2], and (iii) a paramagnetic Fermi liquid [3].

In this work we show that in metallic high-quality silicon MOSFETs, the magnetic field B_c, required to fully polarize electron spins, vanishes at a (low) electron density which is close to n_c, the critical electron density for the $B = 0$ metal-insulator transition. Moreover, B_c is found to be a strictly linear function of electron density (n_s) over a wide range of electron densities: $B_c \propto (n_s - n_c)$. This gives evidence in favor of the existence of a ferromagnetic instability in this strongly correlated 2D electron system.

We have also determined the effective mass, m, and Landé g factor by two independent methods: by measurements of the magnetic field required to fully polarize the electrons' spins and by analysis of the Shubnikov-de Haas oscillations. We have observed a *sharp increase of the effective mass* with decreasing electron density while the g factor remains nearly constant and close to its value in bulk silicon. The corresponding strong rise of the spin susceptibility $\chi \propto gm$, therefore, originates from the enhancement of the effective mass rather than from the increase of g factor, unlike in the Stoner scenario. Furthermore, using tilted magnetic fields, we have found that the enhanced effective mass is independent of the degree of spin polarization and, therefore, its increase is not related to spin exchange effects, in contradiction with existing theories. Our results show that the dilute 2D electron system in silicon behaves well beyond a weakly interacting Fermi liquid.

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[2] E. C. Stoner, Rept. Prog. Phys. **11**, 43 (1947).
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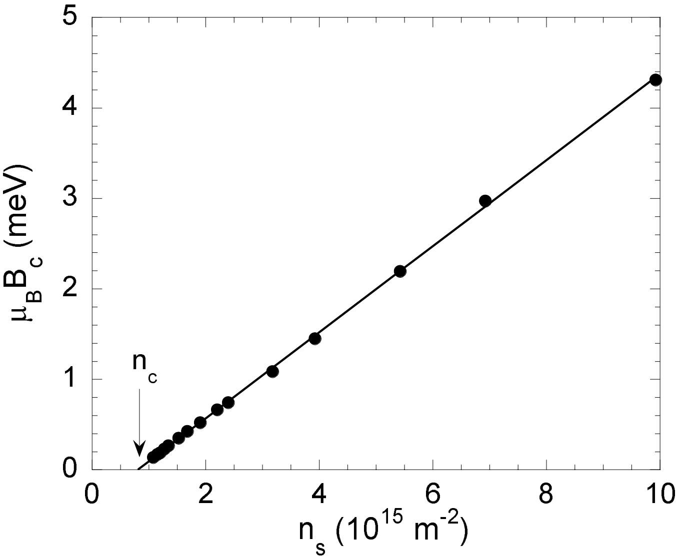

Figure 1: Dependence of the field B_c on electron density. The solid line is a linear fit which extrapolates to the critical electron density for the metal-insulator transition.

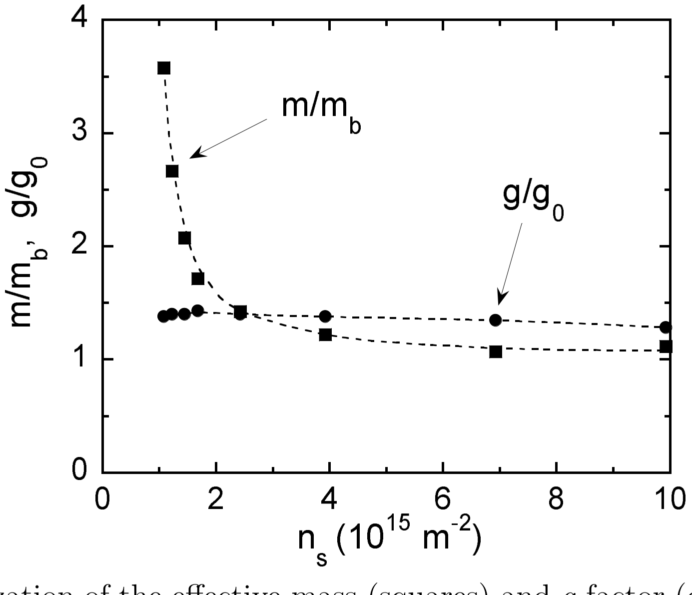

Figure 2: Renormalization of the effective mass (squares) and g factor (circles) as a function of electron density. The dashed lines are guides to the eye.