Magnetoconductivity of a Spin Polarized Two-Dimensional Electron Gas near the (111) Silicon Surface

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During the last decade, the transport properties of strongly correlated and disordered two-dimensional electron systems (2DES) have attracted much interest : indeed, in contrast to the theoretical expectations for non- or weakly ninteracting particles, the resistivity of a high mobility (100) MOSFET has been measured to decrease with temperature [1] and an apparent metal to insulator transition has been observed. Today, the nature of the ground state of the system still remains undetermined : the transport properties of a dilute 2DES when applying an in-plane magnetic field may therefore help to understand whether the anomalous temperature dependence of the conductivity manifests a new electronic state or if it can be understood in the frame of existing theories.

In this paper, we have focused on the parallel magnetoconductance of a 2DEG in a Si MOSFETs near the (111) surface : this highly interacting and disordered system is characterized by a very large value of the r_s factor, about 50 and a nonmonotonic behavior of $\rho(T)$ has been recently observed [2], from which a negative value of the Fermi liquid constant, $F_0^{\sigma} \approx -0.3$ has been derived.
The parallel magnetoconductance has been measured up to 15T, in a very large range of density : from 3 to $90\times10^{11}cm^{-2}$. For the lowest concentrations, a strong negative magnetoconductance attributed to the spin alignment of electrons [3] has been observed, which saturates above the field of complete spin polarization B_c (see Figure 1a). For higher densities, a linear magnetoconductance has been found (see Figure 1b), which is consistent with recent theories based on the screening behavior of spin polarized systems [4].

According to the Fermi Liquid theory, the electron-electron interactions should give rise to a renormalization of the system parameters, including the effective mass m^* and the effective Landé Factor g^*. A sharp increase of the $g^*.m^*$ factor for the lowest densities has indeed been observed in recent studies of the parallel magnetoresistance, in the metallic phase of high-mobility (100) Si-MOSFET [5] : Further studies have shown that this enhancement is due to an increase of the effective mass with decreasing electron density an the spin-independent origin of this increase seems to be contradictory with the occurrence of a ferromagnetic instability.
In our large r_s system, we have determined the value of the $g^*.m^*$ product from the calculation of B_c, field of complete spin polarization. At the lowest densities, Bc has been extracted from the scaling properties [4] of the scaled magnetoconductivity versus B/B_c (see Figure 2). For the higher densities, B_c has been determined from the linear magnetoconductance [6].

Figure 3 summarizes the dependence of g*.m* versus the electron density Ns. One can see some interesting features : In the range < Ns < 8×10^{12}, g*.m* is practically independent of the density. Then for Ns < 2×10^{12} , an increase similar to what is observed in (100) Si-MOSFET, begins. However for Ns < 8×10^{11}, the value of the product proves certainly to decrease. The possible reasons of a so unusual g*m* behavior are analyzed.

References :

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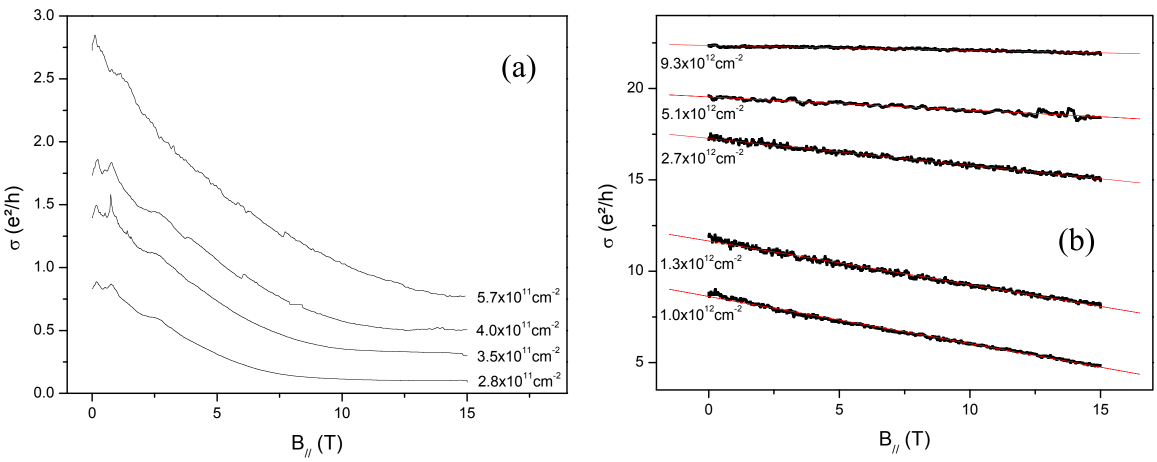
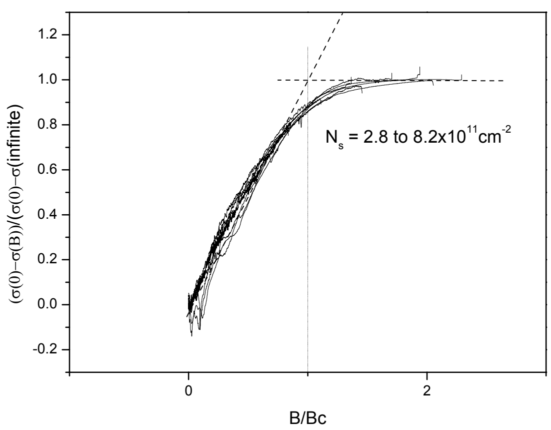


Figure 1 : *In-plane magnetoconductance for various electronic densities, at T=50mK : a) For the low densities, b) for the higher densities.*



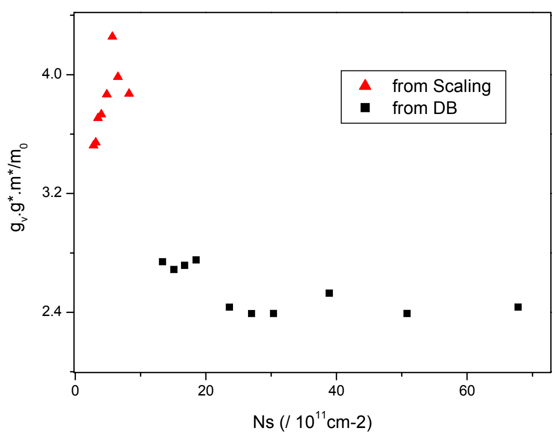


Figure 2 : *(left) Scaled magnetoconductance versus B/Bc, in the low densities region.*
Figure 3 : *(right) g.m product versus electronic density.*