Two-dimensional electron gas near full polarization

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The interest in transport and thermodynamic properties of two-dimensional electron system (2DES) was recently revived by experimental papers reporting metal-insulator transition. It was suggested that all of those data can be described by the Landau Fermi-liquid theory, first derived by Finkelstein for the low temperature diffusive regime and later by three of the authors of this paper for intermediate temperatures. The change in the temperature dependence of the resistivity of the system may be understood in terms of the interaction in the triplet channel; i.e. of the spin exchange interaction. Therefore, it is crucial to work out as many experimentally relevant predictions as possible to test those ideas.

The spin degrees of freedom are clearly affected by the external magnetic field. If the magnetic field is parallel to the 2DES, it does not influence the orbital motion and the only effect is the Zeeman splitting. The Zeeman splitting, $\boldsymbol{E}_z$, quenches the spin fluctuations, thus altering the transport properties of the system. This gives rise to magnetoresistance first discussed by Lee and Ramakrishnan for weak interaction and by Raimondi et al for strong interaction in the diffusive regime. Subsequent studies allowed for the expression of the magnetoresistance in terms of the Fermi liquid constants and generalized the results to the case of higher temperatures.

All of the aforementioned ideas are applicable for the Zeeman splitting much smaller than the Fermi energy, $\boldsymbol{E}_F$. Another interesting aspect of this problem is the opposite limit of the fully polarized electron systems, $\boldsymbol{E}_z > \boldsymbol{E}_F$. It was noticed by Dolgopolov *et. al.* that the temperature dependence of the resistivity of a spin polarized electron system is always insulating. However, the question of how the limits of completely and slightly polarized electron systems match was not addressed in the literature to the best of our knowledge. In this paper we attack this problem in the limit of the almost spin polarized electron system, where the densities of electrons with opposite spins are very different.

We establish the consistency of the Fermi liquid description and find a relation between Fermi liquid constants for a two dimensional electron system near the point of full polarization due to the parallel magnetic field $\boldsymbol{H}$. Our results enable us to predict connections between different thermodynamic properties of the system. In particular, we find that near the point of full polarization $\boldsymbol{H}_c$ the thermodynamic compressibility of the system experiences a jump with the subleading $\sqrt{H_c - H}$ dependence on the magnetic field. Also, the magnetization has a cusp with the dependence of the type $(H - H_c) + (H - H_c)^{3/2}$ at $H < H_c$.