ANISOTROPIC ELECTRONIC TRANSPORT IN TWO-DIMENSIONAL HOLE SYSTEMS

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Introduction

Two-dimensional electron gas (2DEG) in high magnetic field exhibits a multitude of fascinating properties. The strong anisotropy observed around half filling of Landau levels of index N≥2 is one of them; and it has been studied extensively in recent years. In general, this behavior is interpreted as the result of forming charge density waves, due to the breaking of translational symmetry in one direction (1D) and the forming of 1D stripe phases.

Similar anisotropic phases have also been observed in the Si doped two-dimensional hole systems (2DHSs) grown on the (311A) orientation of GaAs. However, these 2DHSs have a large intrinsic mobility anisotropy due to the surface corrugation associated with the reduced symmetry and their complicated band structures. This mobility anisotropy puzzles us to find out the exact physical reason of the observed electronic anisotropy in such systems.

In present, we study 2DHSs confined in GaAs/AlGaAs quantum wells grown on the (100) surface of GaAs. In such systems, we can automatically rule out the mobility anisotropy. A remarkable anisotropy has been observed in lower Landau levels, compared with the 2DEG.

Experimental

Our experiments were operated in the 18/20 T superconducting magnet with dilution refrigerator in SCM1. We performed detailed magnetoresistance (Rxx) measurements and Hall resistance (Rxy) measurements in the temperature range of 20-500 mK and under different tilting angles on 2DHSs. The resistance was measured by conventional quasi-dc lock-in technique (3-4 Hz) using an excitation current of 3-10 nA to prevent electron heating.

Results and Discussion

We observe a strong magnetotransport anisotropy in the N=1 Landau level of 2DHSs, different from the 2DEG in which the anisotropy shows exclusively in the higher Landau levels (N≥2). Under a titled magnetic field, we find that the anisotropy can be either reduced or enhanced by the in-plane magnetic field, depending on the direction of the field with respect to the lattice orientation of the sample. This behavior is again different from the previous reported results in 2DEG, where the anisotropy collapses precipitously as applying a much smaller in-plane magnetic field than what we have applied on the 2DHSs. Particularly, at high tilting angles, we observed a “spike” like feature developed in the magnetoresistance (Rxx) at the filling factor of $2<\nu\leq 5/2$. Although this spike feature looks similar to the resistance spike associated with the first order magnetic transition between quantum Hall ferromagnets, no correlated spike has been observed in the Hall resistance (Rxy) of the sample. At the moment, we are still in progress to understand and interpret our experimental results. However, all our results indicate that the spin related phase in 2DHSs is the key and the interactions between electron spins and the in-plane magnetic field play an important role.

Conclusions

We study the anisotropic electronic transport in 2DHSs at different temperatures and titling angles in high magnetic field in great details. We find that, compared with electron systems, the anisotropy in 2DHSs is shown at lower Landau levels and behaves in a very different matter under a tilted magnetic field. We are still in progress to understand the exact nature of such anisotropy.

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