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Doppler velocimetry of spin and charge currents in the 2D Fermi gas

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Abstract. Phase-sensitive transient grating spectroscopy was used to measure the Doppler shift of light diffracted off moving spin and charge density waves, allowing complete characterization of spin and charge transport in the 2D Fermi gas.

1 Summary of results

We used phase-sensitive transient grating spectroscopy [1] to measure spin and charge transport in a 2D electron gas residing in a GaAs quantum well. We found that spin transport takes the form of helical motion in the presence of linear spin-orbit coupling, and that spin symmetry can be restored in the form of a persistent spin helix [2] with proper tuning of the quantum well growth parameters. Our optical transport measurements show that in a current carrying electron gas, spins and electron-hole pairs are not directly affected by an applied electric field, but rather are pushed along by the force exerted on them by the drifting Fermi sea. Spin diffusion is reduced relative to charge diffusion by electron-electron interactions [3], while the spin mobility is precisely equal to the electron mobility, leading to an anomalous rigidity of spin packets [4] (See Fig. 1). While spin drifts at the velocity of the Fermi sea, electron-hole pairs drift at the much lower ambipolar velocity because of the large hole mass [5].

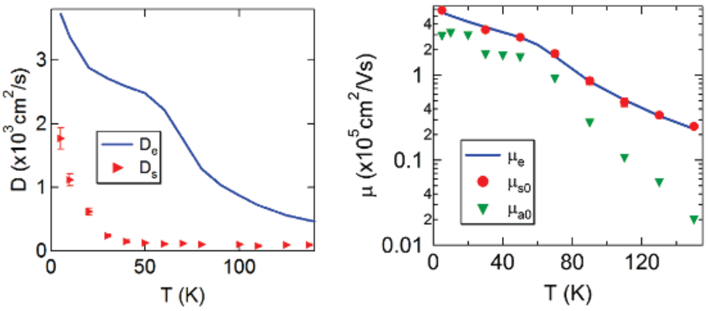

Fig. 1. Spin and charge transport properties. The left panel shows the spin (D_s) and electron (D_e) diffusion coefficients as a function of temperature. The right panel shows the temperature dependence of the spin (μ_{s0}), electron (μ_e) and ambipolar (μ_{a0}) mobilities.

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