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Observation of spin Coulomb drag in a two-dimensional electron gas

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A electron propagating through a solid carries spin in addition to its mass and charge. However, unlike that latter two attributes, the spin of the electron is not a conserved quantity. Despite this fact, it has been widely assumed that for times short compared with the spin relaxation time the spin current obeys the same rules as the charge and mass current (momentum). Of these rules, one of the most fundamental is that the current is not affected by "normal" electron-electron (e-e) collisions, which conserve total momentum. In this talk we demonstrate that this assumption is invalid, and that over a broad temperature range the damping of spin transport in a two-dimensional electron gas (2DEG) is dominated by e-e collisions. In this work spin transport is characterized by the transient spin grating technique [1], which is based on optical injection of spin-polarized electrons. The 2DEG resides in a GaAs quantum well, into which electrons are donated by Si impurites in the GaAlAs barrier layers. Excitation of GaAs with two coherent, orthogonally polarized beams of light generates a wave of electron-spin polarization whose wavevector is controlled by the angle between the two beams. From the spin-density-wave decay rate as a function of wavevector we obtain the spin diffusion coefficient, D_s, in the range T= 5K-295 K. We obtain the charge diffusion coefficient, D_c from 4-contact transport measurements. We find that $D_s$is substantially suppressed compared with D_c. Their ratio yields directly the "spin Coulomb drag" resistivity, $\rho_{\uparrow\downarrow}$, which is proportional to the rate at which e-e collisions transfer momentum between up and down-spin populations [2]. The measured $\rho_{\uparrow\downarrow}$ is in quantitative agreement with theoretical predictions. These results indicate that modeling of spintronic devices in high-mobility semiconductors must include a strong suppression of spin diffusion originating from e-e interactions. In collaboration with C. Weber, N. Gedik, J.E. Moore, J. Stephens, and D.D. Awschalom, and supported by DOE. [1] A.R. Cameron et al., Phys. Rev. Lett. 76, 4793 (1996). [2] I. D'Amico and G. Vignale, Phys. Rev. B 62, 4853 (2000).