MAR05-2004-006262

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Spin susceptibility of AlAs two-dimensional electron systems

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Bulk AlAs has multiple conduction band minima at the X points of the Brillouin zone, giving rise to ellipsoidal conduction electron Fermi surfaces, similar to those of Si, but with only three full ellipsoids occupied. The AlAs electrons have a larger and anisotropic effective mass ($m_l = 1.1$, $m_t = 0.21$) in comparison to the GaAs electrons ($m^* = 0.067$). The effective Lande g-factor of electrons in bulk AlAs ($g^* = 2$) is also much larger in magnitude and of a different sign than in GaAs ($g^* =$ - 0.44). These properties combine to make the AlAs electron system very different from the more commonly studied GaAs system. By confining electrons in modulation-doped AlAs quantum wells we can obtain two-dimensional electron systems (2DESs) with very high low-temperature mobilities. Moreover, by choosing the proper well width, and applying uniaxial stress, we can populate the valleys with their major axis lying either in the 2D plane or out-of-plane. In this talk, we will present results of our measurement of several properties of AlAs 2DESs, with an emphasis on their spin susceptibility. In particular, when the electrons occupy the out-of-plane valley in a very narrow ($<$ 5nm wide) AlAs quantum well, we find that the measured spin susceptibility increases as the density is lowered, quantitatively following the prediction of the quantum Monte Carlo calculations. The measured susceptibility in wider AlAs wells where the electrons occupy the in-plane valleys, however, is puzzling: at a given density, the susceptibility is *larger* when the electrons occupy one valley rather than two valleys. This observation counters the common assumption that a two-valley 2DES is effectively more dilute than a single-valley system because of its smaller Fermi energy. Work performed in collaboration with E.P. DePoortere, O. Gunawan, Y.P. Shkolikov, E. Tutuc, and K. Vakili, and supported by the NSF.