Anomalous Magneto-transport at the Superconducting Interface Between LaAlO3 and SrTiO3

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Introduction
In materials with strong electron correlations a variation of the number of charge carriers may result in a large change in materials properties. It has been demonstrated that the interface between SrTiO3 and LaAlO3 is highly conducting, having the properties of a two dimensional electron gas with superconductivity whose critical temperature can be modified with variation of the gate voltage resulting in a modified carrier concentration.

Experimental
We measured 15 unit cells LaAlO3/SrTiO3 interfaces at 20mK as a function of field up to 18T, orientation and gate voltage (up to 50Volts). The magnetotransport data strongly depend on gate voltage and orientation. We could not exceed a gate voltage greater than 50V. Consequently superconducting transition temperature Tc could not be suppressed to zero on either the overdoped or underdoped sides.

Results and Discussion
We show that both superconducting and magnetic anisotropy can be modified by applying gate voltage. From the length scales deduced from the superconducting parameters we can set an upper limit for the thickness of the charge confinement. This limit decreases with decreasing carrier concentration reaching a minimum of 10 nanometers. In addition we can estimate the effective mass to be 4 times larger than the electron mass. The upper critical field for a field applied parallel to the interface, $H_{c2}$, is approximately the (weak coupling) Pauli limit for high carrier concentrations: $\mu_0H_{c2} = 1.75kT_c$. As the number of charge carriers decreases $H_{c2}$ becomes as large as five times the Pauli limit, suggesting rapidly exceeding spin-orbit coupling. Finally, we identify an energy scale $\varepsilon$ for magnetic scattering increasing with decreasing carrier concentration. $\varepsilon$ becomes too large to be identified when $T_c$ is maximum. In the next session we would like to increase the range of the gate voltage. This will enable us to explore the underdoped (presumably magnetic) region of the phase diagram and the overdoped, non-superconducting region. In addition we would like to vary the number of unit cells and use patterned samples. A higher magnetic field will enable us to observe the saturation in magnetization for parallel field for the -50V gate (see figure).

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References