MAR05-2004-003493

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

Counterflow Conductivity of Bilayer 2D Hole Systems at Filling Factor 1

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Interacting bilayers with no inter-layer tunneling exhibit a peculiar superfluid in perpendicular magnetic fields at total filling factor $\nu = 1$ (layer filling 1/2), when equal and opposite currents are passed in the two layers (counterflow geometry). This phenomenon can be explained by the formation of electron-hole pairs (excitons) in the two, half-filled layers, and the resulting excitonic condensation at the lowest temperatures (T). In this talk we present recent experimental results in strongly interacting GaAs hole bilayers in the limit of zero inter-layer tunneling. Using bilayer samples with independent contacts to each layer, we explore the counterflow transport properties. At the lowest temperatures both Hall and longitudinal counterflow resistivities (ρ_{xx} and ρ_{xy}) vanish at $\nu = 1$, a finding which demonstrates the existence of a counterflow superfluid in the limit of $T = 0$ at this filling factor. A marked feature of our data is that the counterflow ρ_{xy} remains much smaller than the counterflow ρ_{xx} when the temperature is increased. This property becomes more prominent as the bilayer density is reduced, thus placing the bilayer in a stronger inter-layer interaction regime. The counterflow ρ_{xx} at $\nu = 1$ however, shows little dependence on total bilayer density, but can be greatly affected by small changes in the layer charge distribution. Much like the case of superfluid helium, our results can be explained by considering the existence of mobile vortices which move across the superfluid current, thus creating dissipation and finite counterflow ρ_{xx}. The counterflow ρ_{xx} dependence on total bilayer density, as well as layer density imbalance suggests that the vortices are caused by the disorder present in our samples.
Work performed in collaboration with M. Shayergan and D. Huse, and with support from the NSF and DOE.