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Probing Exotic States of Interacting 2 D Electron Systems

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Abstract:

There has been a surge of recent interest in the physics of interacting 2D electrons in a large perpendicular magnetic field when they occupy a half-filled Landau level. The long ago proposed composite fermion (CF) picture, in which two magnetic flux quanta are bound to each electron to form a CF, explains many properties of the system. These include the compressible (metallic) behavior of the 2D system at filling factor $\nu = ½$, the existence of a Fermi sea with a well-defined Fermi wave vector, and the presence of fractional quantum Hall states as the filling deviates from $\nu = ½$. In this talk, I will highlight the results of several recent experiments, performed on very high mobility 2D electron and hole systems confined to GaAs/AlGaAs quantum wells, that probe CFs via measuring the geometric resonance of their cyclotron orbit diameter with the period of an imposed, unidirectional density modulation. The data reveal several important phenomena: (1) An unexpected asymmetry of the CFs' Fermi wave vector for filling factors smaller and larger than $\nu = ½$, suggesting a subtle breaking of particle-hole symmetry. (2) Anisotropic Fermi contours for CFs that can be tuned by applying in-plane magnetic field or in-plane strain. The strain results are particularly intriguing as they imply that the CFs inherit a Fermi sea anisotropy from their (parent) zero-field particles through a simple relation. (3) I will also present CF geometric resonance measurements near the even-denominator fractional quantum Hall state at $\nu = 5/2$, providing direct proof for the existence of fully spin polarized CFs. This observation provides crucial support to the 5/2 fractional quantum Hall effect being a non-Abelian state and therefore of potential use for topological quantum computing.

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