Novel Highly Correlated Ground States in Landau Flat Bands of GaAs/AlGaAs

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The search for novel correlated ground states is a central endeavor in modern condensed matter physics. It is widely recognized that flat electronic bands, may those be Landau bands of flat bands generated at zero magnetic field, greatly enhance electronic correlation effects. Because of the extremely high quality of some two-dimensional electron gases confined to materials, these host materials are known to support novel correlated states in the fractional quantum Hall regime that were not yet measured in flat band systems in the absence of a magnetic field. In this talk we focus on two such recently discovered highly correlated ground states that form at ultra-low temperatures in high quality GaAs/AlGaAs two-dimensional electron gases.

In one experiment we measured a new, fully quantized fractional quantum Hall state at the Landau level filling factor $\nu = 9/11$, see Fig.1. The interesting property of this fractional quantum Hall state is that it cannot be explained based of two-flux or four-flux composite fermions. Instead, one needs to invoke six-flux composite fermions to explain it. Indeed, we could imagine two scenarios to describe such a fractional quantum Hall state, both of which involve six-flux composite fermions in the valence Λ-band. While weak signatures have been seen at filling factors associated with six-flux composite fermions in the extreme quantum limit, topological protection associated with these filling factors was not observed in any of the two-dimensional gases. Our results provide evidence for the formation of the most intricate composite fermion with six fluxes and expands the family of already diverse topological phases with a new member that cannot be characterized by known correlations present in other members. Our observations thus pave the way towards the study of higher order correlations in the fractional quantum Hall regime.

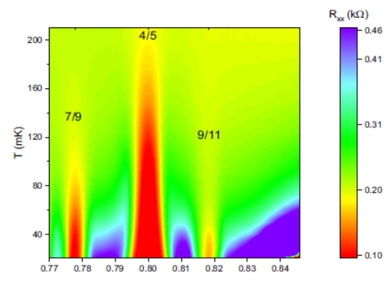

Fig.1. Longitudinal resistance showing the ν=9/11 fractional quantum Hall state associated with six-flux composite fermions.

In another experiment we reported a new phenomenon we dubbed the reentrant fractional quantum Hall effect, see Fig.2. Based on the measured properties we argue that the ground state associated with this effect is a highly correlated state with a bulk that can be described by clustering of the fractionally charged quasiparticles, then an ordering of these clusters on a lattice. We think this ground state is a bubble phase of composite fermions. Our results demonstrate the existence of a new class of strongly correlated topological phases driven by clustering and charge ordering of emergent quasiparticles.

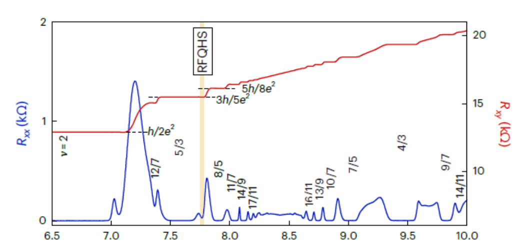

Fig.2. Data exhibiting the reentrant fractional quantum Hall state associated with the bubble phase of composite fermions.

References

[1] H. Huang, W. Hussain, S.A. Myers, L.N. Pfeiffer, K.W. West, K.W. Baldwin, and G.A. Csáthy, Nature Communications **15**, article number 1461 (2024)

[2] V. Shingla, H. Huang, A. Kumar, L.N. Pfeiffer, K.W. West, K.W. Baldwin, and G.A. Csáthy, Nature Physics **19**, 689 (2023)