INVITED

Coexistence of Phases and Gapped Excitations in the Second LL: Fundamental Insights from Inelastic Light Scattering*§

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The competition between quantum phases that dictates the physics in the second Landau level (SLL) results in striking phenomena. Our work explores this fascinating interaction physics by measurements of low-lying neutral excitation modes in the SLL from resonant inelastic light scattering experiments. We focus here on the marked differences of the low-lying collective excitation spectra of the highly enigmatic even-denominator state at Landau level filling $\nu=5/2$, widely believed to support non-Abelian quasi-particle excitations, with those measured in states in the range $5/2>\nu>2$. In the comparisons of observed quasi-particle excitations from different quantum phases we emphasize the results for the state at 5/2 and odd-denominator state at $\nu=7/3=2+1/3$.

Whereas clear low-lying gapped excitations with energies of less than 0.1meV are observable exactly at filling factors representing incompressible FQHE states, these gapped modes completely collapse by very small changes in filling factor of $|\Delta\nu|<0.01$ [1].

The spectra at 5/2 reveal a band of gapped modes with peak intensity at energy of 0.07meV [1]. These modes are interpreted as a roton minimum in the wave vector dispersion of spin-conserving excitations. The intensity of the roton band significantly diminishes by increasing the temperature to 250mK and it fully collapses for T>250mK [1]. This temperature dependence is consistent with activated magneto-transport of the incompressible quantum fluid at 5/2. A long wavelength spin wave mode (SW) is seen at the bare Zeeman energy, indicating that there is non-zero spin-polarization.

The most significant difference for the incompressible fluids away from 5/2 such as 2+1/3 are the coexistence of a gapped lowest energy mode together with a broader band at energies above 0.2meV and a continuum of low-lying excitations. We interpret the coexistence of excitation modes as direct evidence of coexistence and competition of different phases in the second LL. This interpretation is supported by a striking temperature dependence of these modes. The disappearance of the gapped modes by small deviations in filling factor found for $\nu=5/2$ and 2+1/3 and also evident for weaker states at 2+2/5 and 2+3/8 demonstrates a transition from an incompressible quantum Hall fluid to compressible states at very close filling factors.

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