MAR10-2009-003377

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Traversing the States of the Second Landau Level - loss of spin polarization away from ν=3[1]

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The presence of competing liquid and solid ground states as well as intriguing quantum Hall fluids such as that at filling ν=5/2 create great current interest in the partially filled N=1 Landau level. We probe the low-lying collective excitations in quantum phases of the second Landau level by resonant inelastic light scattering. Our work demonstrates that measurements of spin excitations reveal key insights on states of spin, indicating that full spin polarization is lost in the partially populated N=1 Landau level. The long wavelength spin wave mode is seen at the bare Zeeman energy in the fully spin polarized quantum Hall state at ν=3. At filling factors slightly lower (ν=2.97), the intensity of the spin wave mode attenuates and a broad continuum of low-lying excitations emerges. Under these conditions, sharp and broad modes coexist. While the coexistence of spectral features has not been explained, the observation could manifest the presence of mixed quantum phases and some loss of spin polarization. Further below ν=3, near the odd-denominator quantum Hall state at ν=8/3, the continuum dominates at low temperature. A spin wave at the Zeeman energy is not recovered, suggesting loss of spin polarization. In contrast, a well defined spin wave at the Zeeman energy occurs in the analog quantum Hall state at ν=2/3 of the N=0 Landau level [1]. Near the even-denominator state at ν=5/2 light scattering spectra display similar continua of low-lying excitations. At high temperatures (T$\geq$2K) a sharp spin wave is recovered while the broad continuum persists. The absence of a well defined spin wave band at the bare Zeeman energy seems to manifest tendencies towards loss of full spin polarization in the partially populated N=1 Landau level. These findings indicate that spin degrees of freedom have significant impact on the physics of competing phases with filling factors that are in the range 3$\geq$ ν $\geq$2. This work is in collaboration with A. Pinczuk, J. Yan, Y. Gallais, L.N. Pfeifer and K.W. West.

[1] Y. Gallais et al., Physical Review Letters (100) 046804 (2008)

[1]Work supported by NSF under grants DMR-0352738, DMR-0803691, CHE0641523, DOE DE-AIO2-04ER46133 and NYSTAR.