

Skyrmions in integral and fractional quantum Hall effect

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ABSTRACT

The talk will review the physics of skyrmions formed in ferromagnetic quantum Hall states of two-dimensional electrons in a high magnetic field. Skyrmions are remarkable topological vortex-like spin structures, connected through a stereographic projection with the hedgehog spin configuration on a sphere. They carry electric charge, angular momentum, and massive spin, and their emergence as lowest energy charged quasiparticles in a ferromagnetic ground state causes its spin depolarization. It also supports spin-flip excitations with energies below the single-electron spin splitting (Zeeman gap) which can be probed by (e.g.) Raman spectroscopy.

Skyrmions have also been predicted in ferromagnetic fractional quantum Hall (FQH) systems, such as Laughlin incompressible liquid at the Landau level filling factor $\nu=1/3$. Understanding of the FQH effect involves a variety of exotic emergent topological particles, such as fractionally charged quasiparticles, composite fermions (CFs), nonabelian anyons, or Majorana fermions. In particular, the incompressibility and the nature of excitation spectrum of the many known FQH ground states is underlied by the formation of essentially free CFs from strongly correlated electrons – through binding of pairs of quantized vortices of the many-electron wave-function as a result of Coulomb interaction within a degenerate Landau level.

As fractional quantum Hall states of electrons correspond to integral quantum Hall states of CFs, so do fractional skyrmions emerge as topological spin textures in the CF ferromagnets. Owing to different form and reduced energy scale of effective CF interaction, the hypothetical fractional skyrmions are fragile objects, easily suppressed by even fairly weak Zeeman effect.

We find theoretically that the minimal fractional skyrmions exist in the excitation spectrum for a wide range of Zeeman energies slightly away from $\nu=1/3$, and present qualitative and quantitative evidence that the resonances detected in recent Raman scattering experiments just below the long wave length spin wave mode are precisely these fractional skyrmions [1].

References

[1] Balram A. C., Wurstbauer U., Wójs A., Pinczuk A., Jain J. K., *Fractionally charged skyrmions in fractional quantum Hall effect*, Nature Communications 6, 8981 (2015).