Elucidating particle-hole symmetry in the fractional quantum Hall effect

Wei Pan, Sandia National Lab

Symmetry has been a prevalent theme in physics. In the fractional quantum Hall effect (FQHE) realized in a two-dimensional electron system (2DES) at very low cryogenic temperatures and in high magnetic fields, particle-hole symmetry (PHS) plays an important role in our understanding of this exotic effect. Yet, a direct experimental confirmation of PHS has not been made to date, although PHS is often taken for granted. Here, I will report on detailed experimental studies of a high-quality heterojunction insulated-gate field-effect transistor (HIGFET) to probe the PHS of the FQHE states about half-filling in the lowest Landau level. The HIGFET is specially designed to vary the density of 2DES under constant magnetic fields. We find in our constant magnetic field, variable density measurements that the sequence of FQHE states at filling factors nu = 1/3, 2/5, 3/7… and its particle-hole conjugate states at filling factors 1 - nu = 2/3, 3/5, 4/7… have a very similar energy gap. Moreover, a reflection symmetry can be established in the magneto conductivities between the nu and 1 - nu states about half-filling. Our results demonstrate that the FQHE states in the lowest Landau level are manifestly particle-hole symmetric.