Incompressible electron liquids with nonabelian quasiparticles

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The talk will overview the concept of hypothetical nonabelian quantum statistics in two-dimensional electron systems in high magnetic fields, its expectation for the quasiholes of the Moore–Read incompressible liquid at the Landau level (LL) filling factor $\nu = 5/2$, and a new proposal for a nonabelian state *in the lowest LL* (more details follow).

The "second generation" of fractional quantum Hall states [1] include several LL filling fractions ν corresponding to the simple partial fillings ν^* of the second composite fermion (CF) LL (e.g. $\nu = 4/11$ corresponding to $\nu^* = 1/3$). Despite the familiar value of ν^*, this correlated liquid is not a Laughlin state of the CFs. Instead, numerical studies using the effective CF–CF interaction $V_{\rm CF}$ revealed CF pairing at $\nu^* = 1/3$ [2].

Distinct (non-Laughlin) CF–CF correlations originate from ring-like charge-density profiles of the CFs in their second LL. This leads to the effective Haldane pseudopotential $V_{\rm CF}(\mathcal{R})$ with a strong maximum at the relative pair angular momentum $\mathcal{R} = 3$ [3]. This is in contrast to the e–e pseudopotentials in low LLs, with the strongest repulsion at $\mathcal{R} = 1$.

Distinct CF–CF correlations invalidate the reapplication of the "standard" CF transformation (capture of an even number of magnetic flux quanta by each individual particle) to the CFs in the second LL. Nonetheless, numerics (on a sphere) reveals series of finite-size (N-CF) nondegenerate ground states with a gap, including one extrapolating to $\nu^* = 1/3$ as $1/N \to 0$. Relation between N and the CF-LL degeneracy $g^* = 2l^*+1$ (l^* being the CF angular momentum) is $2l^* = 3N-7$ for this series, different from Laughlin's $2l = 3N-3$.

To describe these new states, we propose a generalized CF model which directly incorporates CF pairing and describes the (pair-pair) correlations among many interacting CFs. It provides an intuitive picture for the second generation states observed so far ($\nu^* = 1/2$, $1/3$, and $1/5$) and predicts several other, weak states at $1/3 < \nu^* < 1/5$. When compared with numerical diagonalization, the model correctly predicts the relations $2l^* = N/\nu^* - \gamma$ for finite systems (e.g., the $2l^* = 3N-7$ for $\nu^* = 1/3$).

The main idea of the model is to attach flux to entire pairs. Each individual particle (original CF in the second CF-LL) remains bound within a pair, and moves in an effective magnetic field which includes the smeared flux from all other particles, excluding the other particle from the same pair. This predicts the following expression for effective LL degeneracy: $2l^{**} = 2l^* - p(N-2)$, where p is the attached flux *per particle*.

Most importantly for this talk, excitation spectra slightly away from the complete filling reveal nonabelian quasiparticle statistics. The arguments for nonabelian statistics come from counting of zero-energy eigenstates of a model interaction pseudopotential generating the liquid state itself.

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[3] S.-Y. Lee, V. W. Scarola, and J. K. Jain, Phys. Rev. Lett. **87**, 256803 (2001).