Topological pumping blockade as a signature of FQHE parafermions

Krylo Snizhko, Yanos L. Gersasimenko, and Yuval Gefen

1 Weizmann Institute of Science, Rehovot, Israel
2 Instituut–Lorentz, Universiteit Leiden, The Netherlands

1. Parafermions in FQHE

\[ \hat{a}_i \equiv e^{i \nu (\hat{m}_i + \hat{n}_i)}; \quad \hat{a}_i \hat{a}_i^{\dagger} = 1; \quad \hat{a}_i \hat{a}_j = e^{i \nu \text{sgn}([i-j])} \hat{a}_j \hat{a}_i \]

\[ \langle \hat{r}_i \rangle \hat{a}_i \hat{a}_i^{\dagger} \hat{r}_j \hat{r}_j^{\dagger} = e^{i \nu (\hat{r}_i^{\dagger} \hat{r}_j^{\dagger} + \hat{r}_j \hat{r}_i)} \]

\[ \Rightarrow \hat{a}_i \langle r_i \rangle \hat{a}_j^{\dagger} \sim r + \text{sgn}(i-j) \text{sgn}(j-i) \]

\[ v = \frac{1}{2p+1} \]

Fractional Quantum Hall Effect state

\[ \nu = \frac{1}{2p+1} \]

FQHE state

Parafermions (in domain walls)

Superconductor

4. Lifting the blockade

Unblocking does occur for \( \hat{H}_{\text{tunneling}} = \hat{H}_{\text{tun}} \) or \( \hat{H}_{\text{tunneling}} + \hat{H}_{\text{tun}} \).

For \( l, t \) and \( l', t' \), \( l, t \) or \( l', t' \) are of type \( l_2, l_3 \) or \( l_4 \).

Protocol:

| \( r \neq r_B \) or \( r = r_B \) or \( r = r_B \) or \( r = r_B \) | \( |\psi\rangle = |r_B\rangle \rangle_{AD} \) or \( |\Psi\rangle = \sum_{r, r_B} \langle r | r_B \rangle \rangle_{AD} \)

Outcome \((\nu = \frac{1}{2} r_B = 0)\):

\[ \begin{array}{c} r = 0 \ \text{or} \ r = 5 \end{array} \]

| \( r = 1 \) or \( r = 2 \) or \( r = 3 \) or \( r = 4 \) or \( r = 5 \) or \( r = 6 \) | \( \text{possible topologies for unblocking AD} \)

Conclusion

As the outcome of our work, we built protocols which allow to probe the crucial features of parafermions – nonlocality and statistics.

We calculated the average pumping current and its noise. In each protocol, they take specific values determined by the filling factor \( \nu \) and the topology of a setup.

Being nonlocal, the proposed measurements are robust to local effects, e.g., Andreev bound states, that may mimic parafermions in other experiments.