Violation of the Luttinger's theorem in fractional Chern insulators

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This work investigates single-electron excitations in a fractional Chern insulator. The fractional insulator phase can be described in terms of weakly interacting fractionally charged quasiparticles. However, it was theoretically predicted [1] that the electron is a stable excitation in this strongly correlated liquid. Moreover, using the Luttinger theorem, one can show [2] how electronic correlations are related to the low-energy physics of the fractional quantum Hall effect. The focus of this study is to explore the physics of the fractional quantum Hall effect in lattice systems (fractional Chern insulators) using the Luttinger theorem [3]. In a recent work [2], in a fairly general formulation, it was analytically shown that the theorem is violated in strongly interacting systems, specifically, a non-zero contribution from the Luttinger integral N_2 to the particle density at zero temperature appears.

In this study we analytically and numerically demonstrated a violation of this theorem in the fractional quantum Hall phase, which is associated with the emergence of the Green's function zeros within the single-particle gap. In particular, this leads to a deviation of the many-particle Chern number C from the value N_3, which is an invariant and works well in the integer quantum Hall effect.

The analysis examined the properties of the emerging singularities and their influence on the Hall conductivity σ_{xy} quantization, which is uniquely related to the Chern number. The discovery of Green's function zeros in the spectrum of the system's states is a qualitatively new result for fermionic systems in the fractional phase.

[1] Jain J K and Peterson M R 2005 *Physical review letters* **94** 186808

[2] Peralta Gavensky L, Sachdev S and Goldman N 2023 *PRL* **131** 236601

[3] Luttinger J 1960 *Physical Review* **119** 1153