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Edge mode spectroscopy of fractional Chern insulators

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The exploration of atomic fractional quantum Hall (FQH) states is now within reach in optical-lattice experiments. While bulk signatures have been observed in a system realizing the Hofstadter-Bose-Hubbard model in a box [Leonard et al., Nature 2023], how to access hallmark edge properties in this setting remains a central open question.

We propose and analyze a realistic scheme to extract the momentum-resolved edge spectrum of atomic FQH states. Our proposal is based on subjecting the prepared FQH ground state to two interfering Laguerre-Gaussian beams, which transfer a controlled angular momentum l and energy $\hbar\omega$ to the system. The edge response is then detected through local density measurements, by tracking the transfer of atoms from the bulk to the edge of the FQH droplet. We numerically benchmark our method by considering few bosons in the $\nu = 1/2$ Laughlin ground state of the Hofstadter-Bose-Hubbard model, and demonstrate that our scheme unambiguously reveals its hallmark chiral edge branch. This signature is already detectable in realistic systems of two bosons, provided that the box potential is larger than the droplet. Our work paves the way for the detection of fractional statistics in cold atoms through edge signatures.

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