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Exciton fractional Chern insulators in moiré heterostructures

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Abstract

Moiré materials have emerged as a powerful platform for exploring exotic quantum phases. While recent experiments have unveiled fractional Chern insulators exhibiting the fractional quantum anomalous Hall effect based on electrons or holes, the exploration of analogous many-body states with bosonic constituents remains largely uncharted.

In this work, we predict the emergence of bosonic fractional Chern insulators arising from long-lived excitons in a moiré superlattice formed by twisted bilayer WSe_2 stacked on monolayer $MoSe_2$. Performing exact diagonalization on the topological exciton flat band present in this structure, we provide compelling evidence for the existence of Abelian and non-Abelian phases at band filling ½ and 1, respectively, analogous to bosonic Laughlin and Moore-Read states in Landau levels. The obtained energy gap of 10 meV for the Abelian states suggests a remarkably high stability of this phase, which could in principle be detected as a quantized Hall resistance in counterflow measurements.

Our findings establish the presence of robust exciton fractional Chern insulators in moiré heterostructures, paving the way for the exploration and utilization of strongly correlated topological order of bosons. Moreover, our work unveils a promising pathway for realizing non-Abelian anyons, which can potentially serve as building blocks in fault-tolerant quantum computers.