Fractional quantum anomalous Hall effects in rhombohedral pentalayer graphene

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Abstract: The fractional quantum anomalous Hall (FQAH) effect in rhombohedral pentalayer graphene (PLG) has attracted significant attention due to its potential for observing exotic quantum states [1-3]. This talk will discuss two projects exploring the FQAH effect in PLG. First, we present a self-consistent Hartree-Fock theory focusing on the convergence of the calculation with various reference fields and the stability of the FQAH states [4-5]. We demonstrate that the charge neutrality scheme ensures convergence with respect to the momentum cutoff and provides an unambiguous result. Based on the Hartree-Fock band structure, we perform exact diagonalization calculations to investigate the stability of the FQAH states in PLG. The second project examines the intriguing experimental observation of FQAH states at various fractional fillings giving way to integer quantum anomalous Hall (IQAH) states as the temperature is lowered [3]. We propose a mechanism for the appearance of FQAH states within a finite temperature range using a toy model consisting of a flat Chern band and impurities [6]. The effects of impurities on the system's behavior at finite temperatures are analyzed, and we posit that the crossover may arise from the competition between the energy penalty for thermal excitations and the increase in entropy. Numerical calculations using exact diagonalization support our theoretical argument, suggesting that impurities may play a crucial role in the crossover from FQAH to IQAH states in rhombohedral PLG. Together, these projects provide an improved and unified theoretical framework for understanding the FQAH effect in rhombohedral PLG and pave the way for future studies on this captivating quantum phenomenon.

References

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Figures