Abelian and non-Abelian fractionalized states in twisted MoTe2

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Fractional Chern insulators are lattice analogs of fractional quantum Hall states without an external magnetic field, which have been observed in twisted bilayer $MoTe_2$ ($tMoTe_2$) and moiré rhombohedral multilayer graphene. In this talk, I will present our theoretical study of Abelian and non-Abelian fractionalized states in $tMoTe_2$, utilizing a continuum model derived from first-principles and the framework of generalized Landau levels (LLs). We develop a variational mapping approach to establish a generalized-LL representation of Bloch bands and apply it to the first two moiré Chern bands in $tMoTe_2$. The first moiré band, dominated by the generalized zeroth LL, supports the formation of Abelian fractional Chern insulators within the Jain sequences. The second moiré band is found to be dominated by the generalized first LL at twist angles around 2 degrees. Numerical calculations at the filling factor 5/2 reveal a competition between the non-Abelian Moore-Read state and a charge density wave state, with the transition controlled by bandwidth, as shown in both exact-diagonalization energy spectra and particle entanglement spectra. These results provide a theoretical foundation for the emergence of fractionalized states in moiré materials.