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Excitonic Bose Einstein Condensation in Topological Flat Bands

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概　要

An excitonic insulator (EI) phase can be stabilized in narrow-gap semiconductors/semimetals when spontaneously formed excitons, bound bosonic pairs of electrons and holes, condense at low temperatures. The search for excitonic Bose-Einstein condensate (BEC) in intrinsic semiconductors has received tremendous attention in the past decade, but so far convincing evidence remains lacking. Several material candidates have been recently proposed computationally, but these studies are limited to single exciton calculations and the effects of interactions, if included, are approximated using mean-field approach. In this talk, I will discuss our recent work investigating the role of topological flat bands (FBs) in promoting excitonic BEC. First, I will show that flat valence and conduction bands (so-called yin-yang FBs) of quantum semiconductors [1], such as the one having a diatomic Kagome lattice as exemplified in a superatomic graphene, conspire to indicate a triplet EI state, based on DFT-GW and BSE calculations for a single exciton formation. Next, using exact diagonalization method to solve an extended Hubbard lattice model of yin-yang FBs, I will show directly spontaneous BEC of triplet excitons, based on analyses of multi-exciton formation energies and wave functions [2]. I will demonstrate the critical role of FBs in promoting quantum coherence, as evidenced by off-diagonal long-range order in many-exciton states. These works significantly enriches FB and excitonic physics while providing a unique platform for material realization of spinor BEC and spin superfluidity.

[1] "Flat-Band-Enabled Triplet Excitonic Insulator in a Diatomic Kagome Lattice", G. Sethi, Y. Zhou, L. Zhu, L. Yang, and Feng Liu, Phys. Rev. Lett. **126**, 196403 (2021).
[2] "Excitonic Condensate in Flat Valence and Conduction Bands of Opposite Chirality", G. Sethi, M. Cuma, and Feng Liu, Phys. Rev. Lett. **130**, 186401 (2023).

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