New perspectives on Rydberg excitons in 2D semiconductors

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The reduced dimensionality of 2D semiconductors holds great promise for a wide range of frontier scientific research and applications. In this talk, I would discuss some new perspectives on studying the Rydberg excitons in 2D semiconductors. The Rydberg excitons are higher-order excited Coulomb bound states of electron-hole pairs, known for their large spatial extensions and significantly enhanced sensitivity to the surroundings. First, I will introduce a recently developed Rydberg exciton sensing technique for detecting the correlated electronic states in 2D moiré superlattices, such as the WSe_2/WS_2 moiré heterobilayer and the magic-angle twisted bilayer graphene (TBG) [1-3]. In the latter case, we resolve the correlated Chern insulators (CCIs) under finite magnetic fields and unveil their direct link with the zero-field normal states, the "cascade transitions". Second, I would discuss the observation of Rydberg moiré excitons (Fig. 1), which are moiré-trapped Rydberg excitons in monolayer WSe_2 adjacent to small-angle TBG [4]. These Rydberg moiré excitons manifest as multiple energy splittings, pronounced red shifts, and narrowed linewidths in the reflectance spectra. We attribute these observations to the spatially varying charge distribution in TBG, which creates a highly tunable periodic potential landscape (moiré potential) for trapping and manipulating the Rydberg excitons.

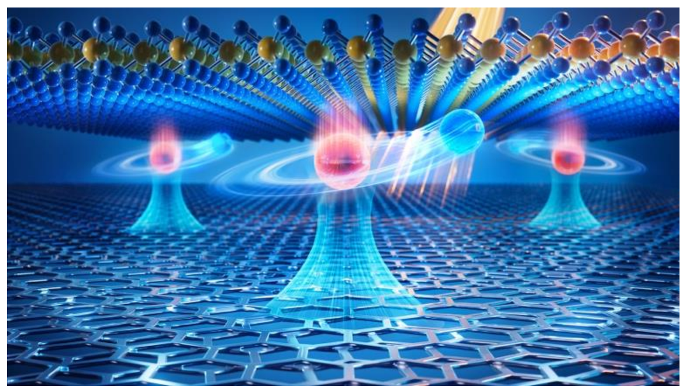

Fig. 1. Illustration of the Rydberg moiré excitons

References

[1] Yang Xu* *et al*., Nature **587**, 214–218 (2020).
[2] Yang Xu *et al*., Nature Materials **20**, 645–649 (2021).
[3] Yang Xu* *et al.*, Nature Nanotechnology **17**, 934-939 (2022).
[4] Qianying Hu *et al*., Science **380**, 1367-1372 (2023).