Designer quantum matter in van der Waals heterostructures

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In my talk, I will show the versatility of employing van der Waals (vdW) heterostructures to engineer artificial electronic phenomena. The vdW systems has recently become de facto platform for the designer materials for its extremely clean, defect-free and atomically well-defined interfaces. These factors make it possible to combine materials with seemingly competing electronic orders such as ferromagnetism, superconductivity.

In the first part of my talk, I will describe the fabrication of designer 2-dimensional topological superconductor having 1-dimensional Majorana edge modes by combining 2D ferromagnet, namely monolayer $CrBr_3$ and s-wave superconductor $NbSe_2$ [1]. I will also demonstrate how the Moire′ pattern between $CrBr_3$ and $NbSe_2$ modulates the topological band structure [2].

In the second part of my talk, I will demonstrate that Kondo coupling between 2 different geometrical phases of TaS_2, namely 1T-TaS_2 having localized magnetic moments and 1H-TaS_2 having itinerant conduction electrons generates artificial heavy fermion system [3] which mimics the behavior of compounds containing rare-earth elements with 4f or 5f electrons.

Finally, I will talk about the signatures of unconventional superconductivity in monolayer transition metal dichalcogenide superconductors 1H-$NbSe_2$ [4] and 1H-TaS_2 [5] demonstrating the role of the dimensionality and confinement in realizing unconventional superconductivity in vdW systems.

References:

[1] Nature 588, 424–428 (2020)

[2] Nano Lett. 22, 1, 328–333 (2022)

[3] Nature 599, 582–586 (2021)

[4] Nano Lett. 2022, 22, 5, 1845–1850

[5] arXiv:2112.07316 (https://doi.org/10.48550/arXiv.2112.07316)