7th International Workshop on 2D Materials

Title of the Presentation: Imaging quantum spin liquid behavior in single-layer 1T-$TaSe_2$

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Short Biography:

Wei Ruan obtained his PhD in physics at Tsinghua in 2017. He has been a postdoc at UC Berkeley since 2017. His research interests lie in the studies of strongly correlated systems, unconventional superconductivity, and novel 2D materials using scanning tunnelling microscopy/spectroscopy.

Abstract:

Quantum spin liquids (QSLs) are a novel state of matter predicted to arise in quantum antiferromagnets where magnetic frustration or quantum fluctuations are strong enough to prevent magnetically ordered states even down to the lowest temperatures. QSLs are believed to exist in strongly correlated Mott insulators, and are thus related to unconventional superconductivity. Much work on QSLs has focused on triangular lattices where frustration is strong. An example is the bulk Mott insulator 1T-TaS_2 which has attracted attention as a QSL candidate due to localized d-orbitals in the Ta atoms that form a triangular lattice in this material. This scenario, however, is complicated by interlayer coupling and possible different stacking orders in the bulk, thus motivating investigation into related single-layer materials.

I will discuss our recent studies on single-layer (SL) 1T-$TaSe_2$ that provide evidence for 2D QSL behavior. We have characterized the electronic structure of SL 1T-$TaSe_2$ (grown via molecular beam epitaxy) by means of scanning tunneling microscopy/spectroscopy (STM/STS), angle-resolved photoemission spectroscopy (ARPES), and first-principles calculations. We observe Mott insulating behavior in SL 1T-$TaSe_2$, including novel orbital texture not seen in bulk samples [1]. Vertical heterostructures formed by a single 1T-$TaSe_2$ layer placed on top of metallic 1H-$TaSe_2$ exhibit Kondo behavior, providing direct evidence for a triangular array of local spins in SL 1T-$TaSe_2$. Evidence for a QSL-based spinon Fermi surface is observed in STM measurements of SL 1T-$TaSe_2$ [2]. These results will be discussed in the context of recent theoretical predictions.

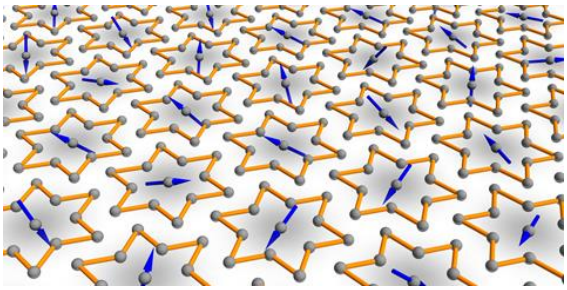

Fig. 1. Cartoon of the star-of-David CDW structure and local spins of single-layer 1T-$TaSe_2$.

[1] Y. Chen et al., Nat. Phys. 16, 218 (2020).
[2] W. Ruan et al., arXiv:2009.07379 (2020).