Controlling charge density order in 2H-TaSe2 using a van Hove singularity

M. Mucha-Kruczynski[1,8]
W. R. B. Luckin[1], Y. Li[2,3], J. Jiang[4], S. M. Gunasekera[1], D. Prabhakaran[5], F. Flicker[6], Y. Chen[5,3,7]
[1]*Department of Physics, University of Bath, Claverton Down, Bath BA2 7AY, United Kingdom*
[2]*Institute for Advanced Studies (IAS), Wuhan University, Wuhan 430072, People's Republic of China*
[3]*School of Physical Science and Technology, ShanghaiTech University, Shanghai 201210, People's Republic of China*
[4]*School of Emerging Technology, University of Science and Technology of China, Hefei 230026, People's Republic of China*
[5]*Department of Physics, University of Oxford, Oxford, OX1 3PU, United Kingdom*
[6]*School of Physics and Astronomy, Cardiff University, Cardiff CF24 3AA, United Kingdom*
[7]*CAS-Shanghai Science Research Center, Shanghai 201210, People's Republic of China*
[8]*Centre for Nanoscience and Nanotechnology, University of Bath, Claverton Down, Bath BA2 7AY, United Kingdom*
m.mucha-kruczynski@bath.ac.uk

The understanding and manipulation of correlated states of matter like superconductivity or ferromagnetism are amongst the principal challenges in physics. From magnetic phases, high-temperature to topological Kagome superconductors and magic-angle twisted bilayer graphene, the correlated states often appear alongside a high density of electron states induced by van Hove singularities (vHs) [1-5]. Here, we report on the interplay between a vHs and a charge density wave (CDW) state in 2HTaSe$_2$. We use angle-resolved photoemission spectroscopy to investigate changes in the Fermi surface of this material under surface doping with potassium. At high doping, we observe modifications which imply the disappearance of the (3×3) CDW and formation of a different correlated state. Using a tight-binding-based approach as well as an effective model, we explain our observations as a consequence of coupling between the single-particle Lifshitz transition, during which the Fermi level passes through a vHs, and the charge density order. The high electronic density of states associated with the vHs induces a change in the periodicity of the CDW from the known (3×3) to a new (2×2) superlattice [6]. Our observation of the (2×2) phase validates a prediction from almost 50 years ago: we present the first spectral evidence of saddle-point nesting-driven CDW in transition metal dichalcogenides as originally proposed [1]. Moreover, the tunability of our system opens a new avenue to explore the interrelationships between CDW, van Hove singularities and superconductivity.

References

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