北京大学量子材料科学中心

International Center for Quantum Materials, PKU

Weekly Seminar

Chiral symmetry breaking, extended flat band and ultrafast dynamics of a Kekulé-ordered graphene

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Abstract

Chirality is a fundamental property for relativistic massless Dirac fermions. Chiral symmetry breaking (CSB), namely, coupling of Dirac fermions with opposite chiralities, could lead to dynamical mass generation for elementary particles. The low-energy excitations of graphene are massless Dirac fermions, and therefore graphene provides a condensed matter physics analogue for investigating CSB and mass generation indicated by band gap opening. Experimental realization and unambiguous observation of CSB are therefore highly desirable in graphene.

Here by combining angle-resolved photoemission spectroscopy and scanning tunneling microscopy measurements, we provide direct experimental evidences for CSB in a Li-intercalated graphene [1]. The CSB is confirmed by CSB induced gap opening in the Dirac cone, Kekulé-O type texture in the surface topography, and chirality mixing near the gap edge. Interestingly, the Kekulé-ordered also shows coexistence of an extended flat band below the Fermi energy and strong electron-phonon interaction, and they codevelop with the Kekulé Order [2]. Moreover, using ultrafast time-resolved ARPES (TrARPES), we have also revealed the self-energy dynamics and phonon-threshold effect for the folded Dirac cone [3]. Our results show that Li-intercalated graphene is a fantastic playground for investigating CSB related physics, flat band instabilities, as well as ultrafast dynamics.

References:

C. Bao, H. Zhang, *et al.*, Phys. Rev. Lett. 126, 206804 (2021)

C. Bao, H. Zhang, *et al.*, Phys. Rev. B 105, L161106 (2022)

H. Zhang, C. Bao, *et al.*, National Science Review nwab175 (2022)

About the speaker

周树云，清华大学物理系教授。2002年本科毕业于清华大学，2007年在加州大学伯克利分校获得博士学位，随后在美国劳伦兹伯克利国家实验室从事博士后研究工作，2012年加入清华大学物理系。主要研究基于激光光源的超快时间（～100飞秒）分辨的超快时间分辨角分辨光电子谱（TrARPES），探索光激发载流子的超快动力学、光导致的弗洛凯能带工程调控及光诱导的瞬态物性调控等。利用NanoARPES、MicroARPES、SpinARPES等精密实验测量技术，探索二维材料异质结的能带调控，尤其是界面耦合、转角、应力等对能带及关联效应的调控作用。基于相关研究在Nature, Nature Physics, Nature Materials, Nature Communications, PRL 等期刊上发表多篇研究论文。先后获得求是杰出青年学者奖（2013），MRS Singapore ICON-2DMAT Young Scientist Award （2017），获第十三届“中国青年女科学家奖”（2017），马丁·伍德爵士(Sir Martin Wood)中国物理科学奖（2018），中国青年五四奖章（2019），黄昆物理奖（2021）。