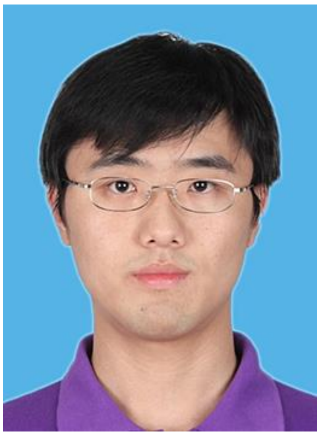
Altermagnet? Novel properties from the crystal-symmetry-paired spin-valley locking



Junwei Liu

Hong Kong University of Science and Technology

Time: 3:00pm, Oct 8, 2024 (Tuesday)

时间: 2024年10月8日（周二）下午3:00

Venue: w663, Physics building, Peking University

地点：北京大学物理楼，西663会议室

Abstract

In this talk, I will present works about our recently proposed crystal-symmetry-paired spin-valley locking (CSVL), which intrinsically exists in spin-splitting antiferromagnetic systems and enables both static and dynamical controls of AFMs [*Nat. Commun. 12, 2846 (2021)*]. Different from the conventional SVL in 2D materials and topological materials, CSVL is enabled by a crystal symmetry instead of the time-reversal symmetry, and hence both spin and valley can be accessed by simply breaking the corresponding crystal symmetry. Typically, one can use a strain field to induce a large net valley polarization/magnetization and use an electric field to generate a large noncollinear spin current even without spin-orbit coupling. Based on symmetry analysis and first-principles calculations, we predicted that CSVL can exist in V_2Se_2O, V_2Te_2O, MnTe, RuO_2, MnF_2, $NaOsO_3$, $LaMnO_3$, $LaCrO_3$, $TbFeO_3$, FeF_2, CoF_2, NiF_2, etc. We have also extended CSVL to all magnetic systems and predicted another 140 experimentally verified AFMs that can realize CSVL [*arXiv:2407.02319 (2024)*].

The predicted spin current and piezomagnetic effect have been confirmed in experiments in RuO_2 [*Nat. Electron. 5, 267 (2022); PRL 129, 137201 (2022); RRL 128, 197202, (2022)*] and in MnTe [*Phys. Rev. Mater. 8, L041402 (2024)*], respectively. The predicted CSVL itself has also been explicitly observed by APRES in KV_2Se_2O [*arXiv:2408.00320 (2024)*], RbV_2Te_2O [*arXiv:2407.19555 (2024)*], MnTe [*Nature 626, 517 (2024)*], $MnTe_2$ [*Nature 626, 523 (2024)*], RuO_2 [*arXiv:2402.04995 (2024)*] and CrSb [*arXiv:2407.13497 (2024)*].

These properties can help us realize the electric readout and 180^o deterministic switching of the Néel order, which has also been confirmed in our recent experimental work [*Sci. Adv. 10, eadn0479 (2024)*]. Due to these unique properties distinct from conventional collinear ferromagnet and antiferromagnet, these materials were proposed to belong to a third type of collinear magnets and were named as altermagnet in 2022 [*Phys. Rev. X 12, 040501 (2022)*]

About the Speaker

Prof. Junwei Liu obtained his PhD in the department of physics, Tsinghua University, in 2014, and then he started his postdoctoral research in Massachusetts Institute of Technology. He joined Hong Kong University of Science and Technology in 2017 as an assistant professor and was promoted to an associate professor in 2023.

Prof. Liu has a broad interest in condensed matter physics and quantum physics, varying from the traditional phenomena like ferroelectricity to the exotic topological phases like quantum spin Hall insulators. His major contributions include (1) theoretical prediction of SnTe-type topological crystalline insulator, WTe_2-type quantum spin Hall insulator and $TaIrTe_4$-type quantum spin Hall insulator; (2) discovery of world-first monolayer ferroelectricity in SnTe thin films; (3) proposal of self-learning Monte Carlo methods that can be thousands of times faster than conventional methods without loss of any accuracy; (4) design and realization of the world-first all-optical neural networks; and (5) proposal of crystal-symmetry-paired spin-valley locking and realization of world-first electrical readout and 180° switching of the Néel order in spin-splitting antiferromagnetic materials. He has published more than 60 papers including 2 in *Science*, 2 in *Nature*, 1 in *Nature Physics*, 3 in *Nature Materials*, 7 in *Nature Communications*, 3 in *Physical Review Letters*, 1 in *Optica*, 1 in *Science Advances*, and 2 in *Nano letters*.