CONDENSED MATTER SCIENCES SEMINAR

Professor Binghai Yan

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Host: Dr Peng Xiong

Spin, Orbital and Charge at Nonequilibrium Phase in Chirality-induced Spin Selectivity

Friday, November 16th, 2024 - 1st Floor B101 - 15:00-16:00

The chirality-spin interaction is a fascinating topic for physicists and chemists. For example, chiral molecules like DNA generate giant spin polarization in nanodevices characterized by large magnetoresistance at room temperature. This phenomenon, called chirality-induced spin selectivity (CISS), paves a pathway for unconventional spintronic devices and enantiomer separation. Two basic questions emerge for CISS. What is the origin of the strong spin-orbit coupling (compared with room temperature) in organic molecules? Why is the CISS spin polarization so large (even larger than the ferromagnet contact)? The first question was recently clarified by an experiment [1] where the heavy-metal electrode contributes significant spin-orbit interaction. The second question refers to a more fundamental topic on the Onsager's reciprocal relation [2]. Distinct from ordinary transport, CISS magnetoresistance violates Onsager's relation, and its physical mechanism remains elusive. In this talk, I will introduce our recent understanding on CISS and understand the chirality-driven phenomena in a unified framework [3]. We propose that the CISS magnetoresistance originates from the charge trapping that modifies the electron tunneling barrier and circumvents Onsager's reciprocity, which is indirectly related to spin. I will introduce more recent experiments [4,5] that verified some exotic predictions from this theory. Our work provides further insights to explore the magnetochiral interaction regarding spin, charge and chirality in chemical and biological interactions.

References:

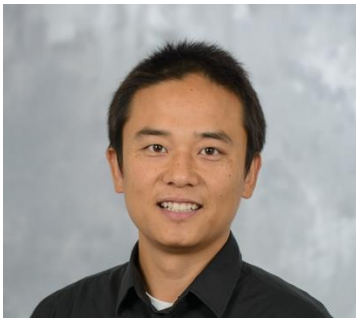
[1] Y. Adhikari, T. Liu *et al*, Nature Comm, 14, 5163 (2023).

[2] B. Yan, Annu. Rev. Mater. Res. 54:97–115 (2024)

[3] J. Xiao, Y. Zhao, B. Yan, arXiv:2201.03623

[4] F. Wu *et al.* arXiv:2408.03501

[5] A. K. Singh *et al.* arXiv:2408.12258



Binghai Yan is an associate professor in the department of condensed matter physics at the Weizmann Institute of Science, Israel. He is a theoretical physicist and currently interested in topological materials and topology-induced phenomena in transport and optics. After completing his PhD at Tsinghua University in 2008, he worked as a postdoc at Bremen University and later at Stanford University. He was a group leader in the Max Planck Institute in Dresden during 2012-2016 and started his current position at Weizmann Institute in 2017. He was awarded the ARCHES Prize in Germany in 2013, the Israel Physical Society Prize for Young Scientist in 2017 and recognized as a Highly Cited Researcher every year since 2019.