Designing quantum materials with strong spin-orbit interaction

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Spin-orbit interaction affects both electronic and magnetic structures of materials and is anticipated to lead to the emergence of novel electronic quantum phases laying the ground to future technologies [1, 2]. Therefore, the materials with a relativistic spin-orbit coupling interaction (SOI) are nowadays in the spotlight. The control of materials and their interfaces is inevitable to unravel the material fundamentals.

In this talk, I will discuss a surprising observation of the SOI in a high mobility two-dimensional electron system of ZnO heterostructures [3]. It constitutes perhaps one of the tantalizing aspects of reach spin physics found in ZnO [4, 5]. Striking here is that the SOI appears in the regime of strong Coulomb interaction, which can potentially lead to the emergence of unconventional electronic and spin phases [2]. Thus, the SOI observation unravels another facet of emerging phenomena in ZnO and marks ZnO as an appealing platform enabling to explore the interplay between correlation effects and the spin-orbit coupling, one of the outstanding problems in modern solid state physics. Furthermore, I will present the recent activities on developing heterostructures based on oxide tantalate material platform, in which both SOI and electron correlation effects are stronger pronounced than in ZnO.

References:

[1] Emergent Phenomena at oxide interfaces, H. Y. Hwang *et al.*, *Nat. Materials* 11, 103 (2012).

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[3] Interplay of spin-orbit coupling and Coulomb interaction in ZnO-based electron system. D. Maryenko *et al.*, *Nat. Comm.* 12, 3180 (2021).

[4] Observation of anomalous Hall effect in a non-magnetic two-dimensional electron system. D. Maryenko *et al.*, *Nat. Comm.* 8, 14777 (2017).

[5] Spin-selective electron quantum transport in nonmagnetic MgZnO/ZnO-heterostructures. D. Maryenko *et al.*, *Phys. Rev. Lett.* 115, 197601 (2015).

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