Symmetry – breaking and electronic properties: from surface states to magnetic semimetals

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Understanding the mechanisms and consequences of the coupling between electronic degrees of freedom and the symmetry of their environment is at the forefront of quantum materials research, offering the exciting opportunity to create, probe and control electronic states of interest. In this talk I will discuss two instances in which the *partial* quenching of angular momentum in the t_{2g} orbital manifold results in unexpected and remarkable consequences for the electronic states.

The first instance are the states localized on the transition metal oxide surfaces of metallic delafossites $PdCoO_2$, $PtCoO_2$ and $PdRhO_2$. Using synchrotron-based spin and angle resolved photoemission (ARPES) spectroscopy to image those states, we have shown that they exhibit spin-splitting of the size of the full atomic spin-orbit coupling of the relevant atoms, in contrast to the usual much smaller effect [1]. Comparing these experimental results, first-principles theory, and minimal tight binding models, we were able to understand how this is a direct consequence of the structural environment of the relevant atom, an insight relevant for design of new materials.

The same structural unit acts as a remarkably sensitive sensor of time reversal symmetry breaking in the antiferromagnetic semiconductor EuCd2P2, a material which stands out due to the unusual temperature dependence of its resistivity: metallic behavior at high temperatures is followed by a 100-fold increase of resistivity with decreasing temperature, culminating in a resistivity peak at 18K, well above the Neel temperature of 11K [2]. We develop an experimental technique employing light to sensitively detect time reversal symmetry breaking through its coupling to electronic degrees of freedom, and use it to uncover a far richer picture of EuCd2P2 than has been previously reported, shedding light on the remarkable resistivity [3]. We discuss the possible consequences of such coupling on other probes of electronic states, such as DC transport and ARPES.

[1] Sunko, V. et al, 2017, Nature 549, 492
[2] Wang et al., 2021, Adv. Mater. 33(10), 2005755
[3] Sunko, V., Sun, Y. et
al, in preparation