Searching for new electronic properties in flat lands of correlated materials

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Dimensionality has profound effects on physical properties of materials. Properties that do not exist in a certain dimension may be realized in systems with a different dimension. Recent surge of studies in 2D van der Waals materials are a good example of such trait of materials. Ideal 2D materials, in the limit of 1 unit cell thickness, may also be achieved by means of more conventional thin film growth techniques. In this colloquium presentation, I will discuss our recent results of in situ angle-resolved photoemission (ARPES) studies on atomically ultrathin transition metal oxide films.

2D spin-polarized band structures of perovskite oxides generally support symmetry-protected nodal lines and points that govern both the sign and the magnitude of the AHE. We performed ARPES studies of ultrathin films of $SrRuO_3$, a prototypical metallic ferromagnet with spin-orbit coupling (SOC). We found there are nodal lines and quadratic band crossing points in ultrathin $SrRuO_3$ films. These symmetry-protected nodal lines and quadratic band crossing points are sources of Berry curvature which causes the observed novel anomalous Hall effects.

We go further and studied 1 unit cell (uc) thick $SrRuO_3$ films. We observe that 1 uc films are not insulator but correlated metal. We can also use strain from various substates and induce metal-insulator transition. This includes octahedron distortions as well as simple strain. We demonstrate that it is possible to change the system from a good metal to a Mott insulator.

Such electronic structure study has been also attempted for ultrathin $SrIrO_3$ as well as a high temperature superconductor $La_{2-x}Sr_xCuO_4$. I will discuss the importance of the study in terms of various symmetry breaking.