Tata Institute of Fundamental Research
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Seminar

Shining Light on Quantum Materials: a combined MBE-ARPES approach

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Quantum materials provide an exciting platform to understand emergent phenomena in condensed matter systems. Our ability to synthesize these materials with atomic precision using molecular-beam epitaxy (MBE) and simultaneously visualize its momentum-space electronic structure via angle-resolved photoemission spectroscopy (ARPES) allows us to gain insights into material systems that has remained out of reach of traditional experimental approaches. It also opens up new possibilities of engineering novel functionalities via materials design.

In this talk, I describe the efficacy of such an approach in three different material systems viz. inter-metallic mixed valence/heavy fermions, topological half-Heusler compounds, and rare-earth monopnictides.

I show how local valence fluctuations connect to momentum space concepts of band filling and Fermi surface topology in a prototypical mixed-valent Kondo lattice system $YbAl_3$, where a decrease in Yb valence leads to a Lifshitz transition and an increased itinerancy of the Yb 4f states. Furthermore, we utilize the observed temperature dependence of the Yb 4f states to demonstrate enhancement of the spin hall effect by f electrons, where a giant spin hall conductivity of 12,000 ħ/2e S/cm is observed at 37 K. Next, I present experimental signatures of topological surface states in PtLuSb, a compound belonging to the multi-functional Heusler family. Utilizing substitutional alloying of Pt with Au in metastable $Pt_xAu_{1-x}LuSb$ epitaxial thin films, we are able to mitigate unintentional p-type doping in the parent compound and tune the chemical potential close to the Dirac point. Finally, I present our recent results on dimensional confinement in a compensated semi-metal LuSb that exhibits large magnetoresistance. By fabricating ultra-thin films, I show that it is possible to controllably create an imbalance in the band fillings of electron and hole-like carriers in this otherwise compensated semi-metal. I conclude with broad prospects of our approach and future directions.

Friday, Sep 21st 2018

4:00 PM (Tea/Coffee at 03:30 PM)

Auditorium, TIFR-H