SES16-2016-000068

Abstract for an Invited Paper
for the SES16 Meeting of
the American Physical Society

Harnessing the f-electron valence in $ThCr_2Si_2$-type compounds[1]

RYAN BAUMBACH, National High Magnetic Field Laboratory - Florida State University

Work during the past several decades has made it increasingly clear that unstable valence correlated electron materials (e.g., cuprates, iron-pnictide/chalcogenides, and f-electron systems) are at the frontier for discoveries. These systems exhibit extraordinary phenomena, including breakdown of Fermi liquid behavior, non-phonon mediated superconductivity, and anomalous ordered states. In spite of intense efforts to unravel their behaviors, they continue to be intractable to theoretical treatments. Equally challenging is that their chemical phase space is enormous, making brute force exploration of real materials ineffective. In this talk, I will discuss a new way to organize the abundant f-electron materials crystallizing in the $ThCr_2Si_2$-type structure, which hosts numerous exemplary correlated electron materials (e.g., the heavy fermion superconductors $CeCu_2Si_2$ and URu_2Si_2). In particular, I will suggest that f-electron materials in this structure are parameterized in two dimensional maps with the axes of unit cell volume and electronic concentration, where the loci of the exotic metallic states coincides with crossover regions between different f-electron valences. This picture unifies earlier work and, importantly, shows that chemical variation on the transition metal or ligand sites explores the 2D phase space along a non-trivial vector. This provides essential guidance for deciding which of these materials might host extraordinary behavior (e.g., quantum criticality, non-Fermi-liquid, anomalous magnetism, and superconductivity) and how to tune them. Importantly, it removes the need for exhaustive expeditions in the chemical phase space, which drastically improves the ability to uncover novel behavior in these and related systems. To examine this picture, I will present results for the chemical substitution series $CeCu_2Si_{2-x}P_x$ and $URu_2Si_{2-x}P_x$, which explore the electron doping vector in their respective phase diagrams. Particular attention will be given to the anomalous high field ordered state in URu_2Si_2 and how it evolves with x.

[1]This work was supported by National Science Foundation Cooperative Agreement No. DMR-0084173, the State of Florida and the DOE. A portion of this work was supported by the NHMFL User Collaboration Grants Program