Materials-driven physics

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Most of the major technological advances of the past several decades have been facilitated by breakthroughs in condensed matter physics that were driven by the discovery of new materials. It is broadly expected that the next generation of technological innovations will depend on properties that emerge from strong electronic correlations in the functional materials of the future. Our ability to efficiently harness such phenomena, including high-temperature superconductivity, metal-insulator transitions, and many others, in materials that are tailored for optimal performance is inexorably coupled to the depth of our understanding of the underlying mechanisms that drive them.

One of the recent discoveries in condensed matter physics is the superconductivity in BiS_2-based compounds. The novel layered superconductors with a BiS_2-based superconducting layer have been discovered in 2012. In short order, other BiS_2-based superconductors with the same or related crystal structures were discovered with T_c up to 10 K. Many experiments were carried out and theories formulated to try to understand the basic properties of these new materials and the mechanism for T_c [1-4].

Beside the superconductivity in BiS_2-based compounds, RTr_2X_{20} (R = rare earth, *Tr* = transition metal, and X = Al, Zn, Cd) compounds have recently attracted much attention because of their unique crystal structure which provides an opportunity to study strongly correlated electronic states, which can be associated with either *f* or *d* electrons, and localized rare-earth magnetic moments that have a large spatial separation compounds [5-7].

In this seminar, I will present results for these and related materials, where a diverse toolbox of synthesis techniques has proven to be essential for uncovering their fundamental behavior. In particular, I will address (1) approaches to uncover new materials which may exhibit new physics, and (2) exploration of phase diagrams in correlated electron materials to search for emergent phenomena and develop physical insight. Based on this work, I will demonstrate that the interface between low temperature techniques and materials synthesis provides an ideal environment for driving advances in condensed matter physics.

References:

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