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Research Interests

In the past few decades, a timely confluence of synthesis of new materials and the development of powerful investigation tools led to new scientific discoveries in condensed matter research. In particular, impressive advances in materials synthesis have resulted in the discovery of an ever-increasing number of complex electron systems exhibiting exotic electronic and magnetic properties, with the most prominent example being the cuprate high temperature superconductors (HTSC) and the colossal magnetoresistive (CMR) manganites. At the same time, the ongoing technological revolution has begun to blur the boundaries between fundamental and applied research, as the physics of low-dimensional systems, nanostructures, and complex materials has also begun to take on a technological relevance. This timely confluence of new materials and investigation tools constitutes a very exciting time and rich of unprecedented opportunities for research in condensed matter physics. The latest advances in materials synthesis allow accessing rich phase diagrams and instabilities towards formation of exotic ordered states by experimentally controlling the dimensionality and external parameters like, for example, temperature, pressure, doping concentration. This possibility offers a plethora of different environments where the coupling of different degrees of freedom can be studied, and model theories for the description of these complex electron systems can be tested.

My main research interests concern the study of the electron correlations and the mechanisms of the interactions among different degrees of freedom in complex electron systems. I am also interested in the study of the effects induced by reduced dimensionality, since a straightforward way to acquire an understanding of how different degrees of freedom of complex electron systems are interacting is to monitor the system as the number of constituent dynamic units is increased.

My research activities are based on the premise that a successful investigation aimed at unveiling the mechanisms of the interactions between different degrees of freedom in these complex materials demands a microscopic and ultimately atom-by-atom characterization of the electronic and crystal structure, including measurements which can accomplish spin-resolution. In my research I make use of spectroscopic and structural probes in the soft x-ray regime currently available at third-generation synchrotron radiation facilities, including angle resolved photoemission spectroscopy (ARPES), core and valence photoemission spectroscopy (PS), photoelectron diffraction (PD), x-ray absorption spectroscopy (XAS), soft x-ray emission spectroscopy (XES), resonant inelastic x-ray scattering (RIXS), and extended x-ray absorption fine structure (EXAFS).

Here at UTK, in collaboration with Hanno Weitering and Ward Plummer, we are currently developing a novel laboratory-based experimental station consisting of state-of-the-art Molecular Beam Epitaxy (MBE), Scanning Tunneling Microscope (STM) and Angle Resolved Photoemission (ARPES) facilities. In particular, the upcoming provision of laser-based photon sources will allow performing ARPES experiments with unprecedented instrumental resolution, while also promising the accomplishment of time resolved ARPES studies of electron dynamics in the sub-picoseconds regime.