

## Research Interests:

My research is concerned with the nature of phase transitions in condensed matter systems, especially strongly correlated systems and quantum matters. More specifically, I am involved with the single crystal growth and using the x-ray scattering, low temperature and high magnetic field measurements, and neutron scattering, as complementary probes to study the spin, electron and structure of solids. Here I will discuss my research interests in five categories:

- (1) Single crystal growth
- (2) Geometrically frustrated magnets (GFM)
- (3) Multiferroic systems
- (4) Systems with strong spin/orbital/lattice coupling
- (5) Systems approaching the itinerant electron limit

### (1) Single crystal growth

My expertise is single crystal growth with Image Furnace by using the TSFZ technique. There is no need to emphasize the importance of single crystal for condensed matter physics research. Every system we start with polycrystalline sample, and then we will pursue to grow large size single crystal to investigate its intrinsic and anisotropic properties, which also makes neutron scattering measurements possible. *The plan is simple, as large as single crystal is better!*

### (2) Geometrically frustrated magnets (GFM)

In the classical limit, liquids are expected to crystallize at low temperatures. Similarly, the spins in a magnetic material are expected to order at a temperature scale determined by the Curie-Weiss temperature  $\theta_{CW}$ . The geometrically frustrated (GF) systems are exceptions. Due to the lattice symmetry, the persistent spin fluctuations can be stabilized well below  $\theta_{CW}$  in GFMs to form exotic ground states. Especially when the spin number is small with  $S = 1/2$  or 1, the quantum spin fluctuations could stabilize quantum spin state such as quantum spin liquid and quantum magnetization plateaus. The motivation is to explore new GFMs and learn the exact behaviors of quantum matters to advance the understanding of them.

### (3) Multiferroic systems

Multiferroics, sometimes called magnetoelectrics, possess two or more switchable states such as polarization, magnetization or strain. The nontrivial spin-lattice coupling in these materials induces surprising magneto-electric (ME) effects. This ME effect is important for potential applications today: the highly efficient control of magnetism by an electric field or electric current in a solid may advance the technology of spin-electronics, such as magnetic storage and magnetic random-access memory. The challenge is still to find ideal multiferroic systems and study their behaviors to understand the microscopic origin

for ME effects. Recently, we focus on multiferroicity in new triangular lattice systems. We try to find systems with coexistence of quantum spin effects and multiferroicity, which is expected to generate new physical behaviors.

#### **(4) Systems with spin/orbital/lattice couplings**

The strong spin-lattice coupling, orbital-lattice coupling, or orbital ordering for orbitals of  $3d$  and  $4d$  electrons are complicated and always related to interesting magnetic, electronic, and structural transitions. The main strategy is to use combination of different measurements to separate the structural, magnetic, and electronic transitions of these complex materials, and further to study the mechanism behind them.

#### **(5) Systems approaching the itinerant electron limit**

Metal oxides or itinerant electronic behavior in oxides are related to many exciting physical properties, such as metal-insulator transition, heavy fermions, and superconductors. In general, the electronic behavior for a transition-metal oxide is controlled by the tight-binding bandwidth ( $W$ ) and the on-site electrostatic Coulomb energy separating the redox of  $3d$  ions ( $U$ ). The Mott–Hubbard transition ( $W \approx U$ ) should be first order and therefore that the crossover from itinerant to localized electronic behavior should be characterized by a phase separation, one phase containing itinerant electrons and the other strongly correlated or localized electrons. Then heterogeneous electronic behavior happens for the samples sitting on the edge of the transition. The goal is to find new systems to deeply study this kind of electronic phase separation behaviors.