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Orbital exchange and fractional quantum number excitations in $\text{Yb}_2\text{Pt}_2\text{Pb}$

Strongly correlated electron systems display a variety of orders, and it is increasingly believed that these phases may be organized at $T=0$ in a universal phase diagram with two different sources of quantum criticality. The interplay between electronic delocalization driven by coupling between the conduction electrons and localized moments can lead to a transition or crossover between two phases with different sized Fermi surfaces, although a purely magnetic transition may be found in systems with strong quantum fluctuations, due to low dimensionality or geometrical frustration.

$\text{Yb}_2\text{Pt}_2\text{Pb}$ is a promising example of a magnetically frustrated system where Yb moments with strong Ising anisotropy lie on orthogonal spin ladders. Although these moments might be considered classical, being in a nearly pure state with $j_Z = \pm 7/2$, neutron scattering measurements find an incoherent continuum of magnetic excitations, direct evidence that electrons carry a fractional spin quantum number. These excitations disperse only along the chain direction, and they resemble the spinon dispersion that is found in $S=1/2$ Heisenberg spin chains with only weak magnetic anisotropy. This unexpected quantum behavior emerges at low energies from the competition between strong onsite and spin-orbit interactions, the crystal fields, and the intersite hopping, all acting on much higher energy scales.

Meigan Aronson works in experimental condensed matter physics, with emphasis on the discovery and characterization of new compounds where different types of electronic order can be induced to occur exactly at zero temperature. The unusual quantum critical phenomena associated with these $T=0$ phase transitions are explored in materials as diverse as f-electron based heavy fermion compounds, low dimensional d-electron compounds that are proximate to insulator-metal transitions, and unconventional surface states in topological insulators. Prof. Aronson received her A.B. from Bryn Mawr College in 1980, and the M.S and Ph.D degrees from the University of Illinois at Urbana-Champaign in 1982 and 1988. Following a postdoc at Los Alamos National Laboratory, she joined the Physics faculty at the University of Michigan in 1990. She moved her lab in 2007 to Stony Brook University, where she held a joint position between the Department of Physics and Astronomy, and Brookhaven National Laboratory. She joined Texas A&M University in 2015, where she is both the Dean of the College of Science as well as a professor in the Department of Physics and Astronomy.



Cristian D. Batista, Ph.D.

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Exotic orderings in frustrated itinerant magnets

In a seminal work, Haldane demonstrated that a magnetic field is not required to induce integer quantum Hall states [1]. Adding a complex hopping to the tight-binding Hamiltonian on the honeycomb lattice opens a gap at the Dirac points of the electron band structure. This gap leads to a topologically nontrivial electronic state for a half-filled band, i.e., a Chern insulator or quantum anomalous Hall (QAH) state. I will show that effective magnetic fluxes, like the ones that Haldane included in the honeycomb lattice, can be spontaneously generated in Kondo lattice systems out non-coplanar magnetic orderings induced by the exchange coupling between localized magnetic moments and itinerant electrons. Besides the quantum anomalous Hall state [2-5], we will see that these non-coplanar spin orderings can also lead to other topologically non-trivial band structures and to rather exotic states of matter, such as vortex crystals and chiral stripes.

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Cristian D. Batista works in theoretical condensed matter physics, with emphasis on strongly correlated electron systems. One area of Prof. Batista's current interest is the emergence of complex magnetic orderings from frustrated interactions. In particular, he and his collaborators discovered that, unlike local moment Mott insulating systems, non-coplanar chiral magnetic orderings are rather ubiquitous in frustrated itinerant magnets. They have demonstrated that these exotic orderings, which often correspond to crystals of topological structures, such as magnetic vortices and skyrmions, have their roots in effective interactions, which are not contained in the lowest order RKKY Hamiltonian. Another focus of Prof. Batista's current research concerns spin liquids and charge effects in Mott insulators. Prof. Batista obtained his B.S. degree in Physics from the Instituto Balseiro (S. C. Bariloche) Argentina in 1992, and his Ph.D. degree in Physics from the Instituto Balseiro in 1996. He did his postdoctoral work at the Los Alamos National Laboratory as a JRO fellow. In 2004 he joined the Los Alamos Laboratory as a staff member. In 2016, he will join the University of Tennessee as the Willis Lincoln Chair of Excellence in Physics Professor of Physics. Prof. Batista was elected Fellow of the American Physical Society in 2014.



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Nematicity and magnetism in iron-based superconductors

In the iron-based materials, superconductivity usually emerges when a stripe-type antiferromagnetic phase is suppressed by either doping or pressure. This magnetic phase transition is accompanied or sometimes even preceded by a tetragonal-to-orthorhombic structural distortion. The transition has been termed nematic, by analogy to a liquid crystal phase, and a lively debate concerning the origin of the orthorhombic-magnetic phase has ensued the discovery.

I will present the elastic shear modulus of various iron-based systems obtained in a novel high-resolution three-point bending setup and show how the shear modulus can be related to the nematic susceptibility [1]. These thermodynamic data will be compared with other probes of the nematic susceptibility, such as the elastoresistivity and the electronic Raman response function (see [2]). In a scenario in which the nematic transition has a magnetic origin, the nematic susceptibility can further be linked to the spin-lattice relaxation rate in nuclear magnetic resonance, and an experimental test of this relationship will be presented [3]. Finally, the special role of FeSe, a material possibly showing nematicity of non-magnetic origin, will be discussed [4].

[1] A. E. Böhmer, et al., *Phys. Rev. Lett.* 112, 047001 (2014).

[2] A. Böhmer and C. Meingast, *Comptes Rendus Physique*, doi:10.1016/j.crhy.2015.07.001 (2015).

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Anna Böhmer works on crystal growth, characterization and thermodynamic measurements of strongly-correlated electron systems, mostly iron-based superconductors. She has developed a high-resolution three-point bending method for elastic-modulus measurements and used it to investigate nematicity in iron-based systems. Her studies on vapor-transport grown FeSe raised the question of a possible non-magnetic origin of nematicity. Further, her detailed thermodynamic investigation of K-doped BaFe₂As₂ revealed the presence of a tetragonal (C4) magnetic phase and its strong competition with superconductivity. Anna Böhmer received a double-diploma from the Karlsruhe Institute of Technology (KIT) and from the Ecole Polytechnique in Palaiseau in 2011 and a Ph.D. from KIT in 2014. She is currently a postdoc with Paul Canfield at the Ames Laboratory. She was awarded the Karl-Freudenberg Prize of the Heidelberg Academy of Sciences in 2015 for her thesis work.



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The evolution of the electronic structure of FeSe with chemical pressure

FeSe is structurally the simplest iron-based superconductor [1] but one of the most intriguing electronically, with extreme tunability in its electronic and superconducting properties. With a superconducting transition of 9K, FeSe undergoes a structural transition around 87K but does not order magnetically at any temperature. Furthermore, it shows a strong increase of its superconducting transition temperature towards 40K under applied pressure, or by intercalating with various organic and non-organic elements between its van-der Waals layers as well as by doping its surface.

I will discuss the evolution of the electronic structure of FeSe and provide evidence that its structural transition is electronically driven. Using high-resolution ARPES data we track the Fermi surface deformation from four-fold to two-fold symmetry across the structural transition, as a result of the dramatic splitting of bands with dxz and dyz character in the presence of strong electronic interactions [2]. I will discuss the details of the low-temperature Fermi surface, which consists of one hole and two electron bands and is fully determined by combining the knowledge from ARPES and quantum oscillations [2]. This Fermi surface can also explain the magnetotransport data in high magnetic fields, which reveal the presence of a high mobility electronic band [3]. Our elastoresistance measurements on FeSe show the divergence of the nematic susceptibility, when approaching the structural transition, supporting the electronically-driven scenario for this transition [2]. I will also discuss the effect of chemical pressure on FeSe, using isovalent substitution of S onto the Se site, which subtly modifies the electronic structure of FeSe and induces a suppression of the structural transition temperature using ARPES [4] and quantum oscillations studies.

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Amalia Coldea is Research Fellow in Experimental Condensed Matter Physics at the University of Oxford working on electronic structure of novel quantum materials. She is funded by a prestigious EPSRC Career Acceleration Fellowship and she holds a Senior Research Fellow at Somerville College, Oxford. Previously, she held a Royal Society Dorothy Hodgkin Fellowship at the University of Bristol and University of Oxford. She was a Departmental Lecturer and Post-Doctoral Research Assistant at the University of Oxford, just after obtaining her PhD degree in Physics at the Queen's College in Oxford. She has carried out her experimental research in condensed matter physics on part-time basis combined with raising two small children. She was awarded the EuroMagnet prize 2011 for her outstanding contribution to the understanding of the electronic structure of iron-based superconductors using high magnetic fields.



Onur Erten, Ph.D.

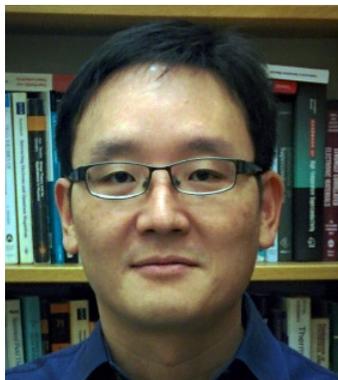
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Kondo breakdown in topological Kondo insulators

Motivated by the observation of light surface states in SmB₆, we examine the effects of surface Kondo breakdown in topological Kondo insulators. We present both numerical and analytic results which show that the decoupling of the localized moments at the surface disturbs the compensation between light and heavy electrons and dopes the Dirac cone. Dispersion of these uncompensated surface states is dominated by intersite hopping, which leads to much lighter quasiparticles. These surface states are also highly durable against the effects of surface magnetism and decreasing thickness of the sample[1].

[1] V. Alexandrov, P. Coleman, O. Erten *Phys. Rev. Lett.* 114, 177202 (2015)

Onur Erten's research interests lie in the field of theoretical condensed matter physics: strongly correlated electron systems, quantum magnetism, unconventional superconductivity and topological phases in heavy fermions and transition metal oxides. Dr. Erten obtained his B.S. degree in Physics from Bilkent University in Ankara, Turkey in 2008, and his Ph.D. degree in Physics from the Ohio State University in 2013. He is currently a postdoctoral associate at Center for Materials Theory at Rutgers University.



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Resonant Inelastic X-ray Scattering (RIXS) study of strongly correlated materials

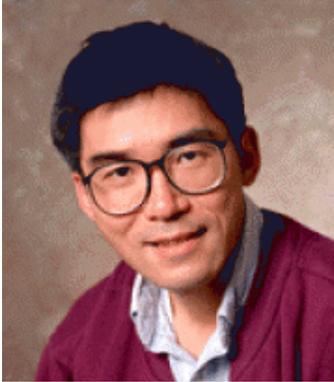
Recent advances in instrumentation and theoretical understanding have made resonant inelastic x-ray scattering (RIXS) an important research tool for studying momentum dependent collective excitations in strongly correlated electron systems, such as cuprates and iridates. Due to strong spin-orbit interaction and electronic correlation, iridates host a number of interesting quantum phases of matter. A broad overview of recent RIXS studies of iridates on honeycomb, pyrochlore, and square lattices will be given. In particular, we will focus on square lattice iridates, which exhibit physical and magnetic properties remarkably similar to those of cuprates, such as quasi-two-dimensional magnetism and very large magnetic exchange [1]. The evolution of magnetic excitation spectra as charge carriers are doped into Sr₂IrO₄ will be examined and compared with that in cuprate superconductors. We will discuss both hole and electron doped samples, obtained by partially replacing Ir⁴⁺ ions with Rh³⁺ ions, and Sr²⁺ ions with La³⁺ ions, respectively [2-3].

[1] Jungho Kim, et al. *Phys. Rev. Lett.* 108, 177003 (2012).

[2] J. P. Clancy et al., *Phys. Rev. B* 89, 054409 (2014).

[3] Xiang Chen et al., *Phys. Rev. B* 92, 075125 (2015).

Young-June Kim is a professor of physics at University of Toronto. His research group focuses on synthesizing novel quantum materials and studying their physical properties using advanced x-ray and neutron spectroscopy methods. His research interest spans a wide range of quantum condensed matter physics, such as superconductivity, quantum magnetism, novel topological quantum phases, and thermoelectric materials. In particular, he played an instrumental role in developing a new synchrotron based x-ray technique called resonant inelastic x-ray scattering (RIXS). He is also the director of HEATER program, a multi-institution research and training program in thermoelectric materials. Prof. Kim obtained his B.S. degree in Physics from Seoul National University in 1993, and his Ph.D. degree in Applied Physics from Harvard University 1999. He did his postdoctoral works at Massachusetts Institute of Technology and Brookhaven National Laboratory. In 2004 he joined University of Toronto as an assistant professor and Canada Research Chair in complex materials.



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A novel nematic quantum paramagnet in iron-based superconductor FeSe

A quantum paramagnet is a gapped state of quantum spins, where the spin rotation symmetry remains unbroken even at zero temperature. Discovering this type of state in real materials attracts strong interest in condensed matter physics. In this talk I shall make the case that such a state is realized in FeSe, a member of the iron-based high temperature superconductors. Interestingly the mechanism for this novel state is topological in origin [1]

[1] F. Wang, S.A. Kivelson and D.-H. Lee, *Nature Physics* online published

Dung-Hai Lee is a theoretical condensed matter physicist. The principal goal of his research is to uncover new states of matter and understand their physical properties. He approaches this goal by engaging in three different types of research activity: 1. theoretically proposing new states of matter that transcend conventional paradigms, 2. performing analytic or numerical computation on models of strongly correlated systems, and 3. constructing phenomenological theory to extract the underlying physics from important experiments. Throughout the past ten years, he has worked on problems related to high-transition temperature superconductivity, photoisomerization, the fractional quantum Hall effect, superconducting nano wires, graphene, KxC60 monolayers, strongly correlated one dimensional systems, time-reversal symmetry breaking superconductors, frustrated spin models, carbon nano tubes, and transport of electron in strong magnetic fields and disorder media.



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Robust nematic state in electron-doped pnictides

The phase diagram of electron-doped pnictides as a function of temperature, electronic density, and isotropic quenched disorder strength obtained by means of computational techniques applied to a three-orbital (xz, yz, xy) spin-fermion model with lattice degrees of freedom will be presented. In experiments, chemical doping introduces disorder but in theoretical studies the relationship between electronic doping and the randomly located dopants, with their associated quenched disorder, is difficult to address. The use of computational techniques allows to study independently the effects of electronic doping, regulated by a global chemical potential, and impurity disorder at randomly selected sites. Surprisingly, Monte Carlo simulations reveal that the fast reduction with doping of the Néel TN and the structural TS transition temperatures, and the concomitant stabilization of a robust nematic state, is primarily controlled by the magnetic dilution associated with the in-plane isotropic disorder introduced by Fe substitution. In the doping range considered, changes in the Fermi Surface produced by electron doping affect only slightly both critical temperatures. Comparisons with STM and neutron scattering experiments will be presented.[1]

[1] S. Liang, C. Bishop, A. Moreo and E. Dagotto, *Phys. Rev. B* 92, 104512 (2015).

Adriana Moreo works in theoretical condensed matter physics. Her main professional interests are strongly correlated electrons, high critical temperature superconductors, colossal magnetoresistive manganites, magnetism; numerical methods, and computational physics. Prof. Moreo obtained her M.S. degree in Physics in 1983 and her Ph.D. degree in Physics in 1985 at the Instituto Balseiro in Argentina. She did her postdoctoral work at the University of Illinois at Urbana-Champaign and at the University of California in Santa Barbara. In 1992 she joined the faculty of Florida State University, where she advanced to the rank of professor in 1999. In 2004 she joined the faculty of the University of Tennessee at Knoxville as a professor and became joint faculty at Oak Ridge National Lab. Prof. Moreo was named a Fellow of the American Physical Society in 2002.



Satoru Nakatsuji, Ph.D.

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Exotic topological states near a quantum metal-insulator transition in pyrochlore iridates

Pyrochlore iridates have attracted great interest as prime candidates that may host topologically non-trivial states, spin ice ordering and quantum spin liquid states, in particular through the interplay between different degrees of freedom, such as local moments and mobile electrons. Based on our extensive study using our high quality single crystals, we will discuss such examples, i.e. chiral spin liquid in a quadratic band touching state and Weyl semimetallic state nearby a quantum insulator-semimetal transition in pyrochlore iridates.

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Satoru Nakatsuji, an associate professor at Institute for Solid State Physics (ISSP), University of Tokyo, obtained his B. Eng. (1996), M. Sc. (1998) and D. Sc. (2001) degrees from Kyoto University. He was a JSPS research fellow at National High Magnetic Field Laboratory in Florida, U.S.A (2001–2003), and a lecturer at Department of Physics, Kyoto University (2003-2006). He has been an associate professor at ISSP since 2006, and was also visiting associate professor at Osaka Univ. (2012-2015). He is also currently a PRESTO researcher of JST. He and his group are working on new material syntheses and low temperature measurements to study various transport and thermodynamic phenomena down to mK range, focusing on strongly correlated systems, which exhibits novel topological phases, geometrically frustrated magnetism, multipolar ordering, quantum criticality, unconventional superconductivity. He received a JSPS Prize from the Japanese Society of Promotion of Science in 2015, a Japan Academy Medal from Japan Academy in 2015.



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Optical conductivity in the cuprates from holography and unparticles

Two features of the optical conductivity in the cuprates that remain unresolved are the 1) power-law scaling with frequency in the mid-infrared and 2) a violation of the f-sum rule. So befuddling is the former that even high-energy theorists have written papers on the puzzling $\omega^{-2/3}$ scaling law in the cuprates. The key claim here is that the observed power law is a universal consequence of gravity in the presence of translational symmetry breaking. I will explain this claim and report on a calculation that tests it. I will show that the general claim is not true. As an alternative, I will show how unparticles or a scale invariant sector in the mid-infrared can account for the experimentally observed power law and a violation of the f-sum rule. I will close by showing how a recent mapping between unparticles and massive gravity offers a window into how gravity might underlie the physics of the cuprates.

Philip Phillips received his bachelor's degree from Walla Walla College in 1979, and his Ph.D. from the University of Washington in 1982. After a Miller Fellowship at Berkeley, he joined the faculty at Massachusetts Institute of Technology (1984-1993). Professor Phillips came to the University of Illinois in 1993. Professor Phillips is a theoretical condensed matter physicist who has an international reputation for his work on transport in disordered and strongly correlated low-dimensional systems. He is the inventor of various models for Bose metals, Mottness, and the random dimer model, which exhibits extended states in one dimension, thereby representing an exception to the localization theorem of Anderson's.

His research focuses sharply on explaining current experimental observations that challenge the standard paradigms of electron transport and magnetism in solid state physics. Departures from paradigms tell us that there is much to learn. Such departures are expected to occur in the presence of strong-electron interactions, disorder, and in the vicinity of zero-temperature quantum critical points. The common question posed by experiments that probe such physics is quite general. Simply, how do strong Coulomb interactions and disorder conspire to mediate zero-temperature states of matter? It is precisely the strongly interacting electron problem or any strongly coupled problem for that matter, such as quark confinement, that represents one of the yet-unconquered frontiers in physics. Understanding the physics of strong coupling is Phillips' primary focus.



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The possibility of an orbitally selective Kondo effect in $\text{SrFe}_{2-x}\text{Ni}_x\text{As}_2$.

Though one can describe many aspects of the iron-based superconductors within an itinerant electron approach, there is also substantial evidence that a local moment description must be included as well. Given the strong similarities between the P-T phase diagrams of AFe_2As_2 ($A=\text{Ba, Sr, Ca}$) and Ce-based heavy fermion such as CeMIn_5 ($M=\text{Co, Rh, Ir}$), we were motivated to understand the response of the system if we could examine an individual Fe atom in a non-magnetic analog. In this case we chose SrNi_2As_2 , a paramagnetic metal, as the non-magnetic host. For dilute Fe concentrations ($< 1\%$) in SrNi_2As_2 we observe the single ion Kondo effect in transport and thermodynamic measurements, with $S=1/2$ and $T_K \sim 5$ K. Increasing the iron concentration leads to a breakdown of the single ion scaling and a dramatic increase in the characteristic energy scale in the system. A similar renormalization of the Kondo scale is observed in the LaMIn_5 systems with increasing Ce concentration. We will discuss the surprising presence of the Kondo effect in the Fe-based superconductors, their similarities with heavy fermion materials, and whether it is appropriate to separate the spin and charge degrees of freedom.

Filip Ronning received his B.A. in physics summa cum laude from Cornell University in 1996 and subsequently received his Ph.D. from Stanford University in 2001 for angle resolved photoemission work on strongly correlated oxides. Following two years at the University of Toronto performing ultrasound and thermal conductivity measurements at temperatures down to 40mK in the lab of Louis Taillefer, he joined Los Alamos National Laboratory in 2003 as a distinguished Reines postdoctoral fellow. As a staff member his current interests are in transport and thermodynamic measurements under extremes of pressure, temperature, and magnetic field of strongly correlated systems to elucidate new physics through new materials. He has coauthored over 200 peer-reviewed publications, with more than 5500 citations. In 2015 he was elected fellow of the American Physical Society.



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Correlation induced insulating behavior and antiferromagnetic order in $\text{NaFe}_{1-x}\text{Cu}_x\text{As}$

Superconductivity in the cuprates emerges from strongly correlated Mott insulators through carrier doping, in contrast superconductivity in iron pnictides arise from metallic parent compounds. The question whether iron pnictides are affected by a proximate Mott insulating state [1] determines whether weakling coupling theories can fully capture the physics of these materials or electronic correlations is a necessary ingredient. So far experimental evidence on this front is lacking.

I will discuss our recent observation of a metal-insulator transition with increasing doping in $\text{NaFe}_{1-x}\text{Cu}_x\text{As}$. Based on the observation of concurrent development of magnetic order and theoretical considerations we argue that the insulating behavior is driven by enhanced electronic correlations [2]. The magnetic order in NaFeAs (0.1 μB) is quickly suppressed with doping near $x \sim 1.5\%$, for $x \sim 18\%$ a separate short-range glassy magnetic order develops. With x approaching 50%, the magnetic order becomes long range and static with ordered moment $> 1\mu\text{B}$. We show for this regime Cu is nonmagnetic and the magnetism is solely due to Fe. Furthermore, Fe and Cu order into stripes forming a structural analog of the magnetic order in NaFeAs . Combined with recent STM results [3] that suggest the electronic density of states of the system is similar to lightly doped cuprates, our work point to a strongly correlated insulating state at $x = 0.5$ that can be interpreted as the parent phase within a universal phase diagram of iron pnictides and cuprates [4].

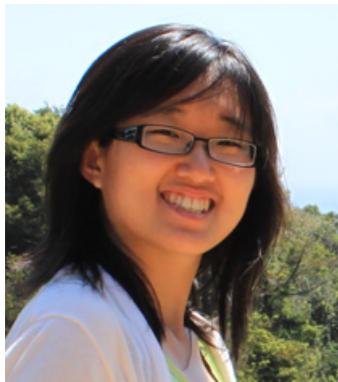
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[2] Yu Song et al., *arXiv: 1504.05116*

[3] C. Ye et al., *Phys. Rev. X* 5, 021013 (2015)

[4] L. de' Medici et al., *Phys. Rev. Lett.* 112, 177001 (2014)

Yu Song is a graduate student at Rice University in Pengcheng Dai's research group working on experimental condensed matter physics. He is interested in experimentally studying strongly correlated materials using transport, magnetization and x-ray & neutron scattering techniques. He obtained his Bachelor's degree in 2010 from Zhejiang University.



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Strong correlation effects in iron chalcogenide superconductors

The iron chalcogenide superconductors constitute arguably one of the most intriguing families of the iron-based high temperature superconductors given their ability to superconduct at comparable temperatures as the iron pnictides, despite the lack of similarities in their magnetic structures and Fermi surface topologies. In particular, the lack of hole Fermi pockets at the Brillouin zone center put serious doubt on the previous proposal of spin fluctuation mediated pairing via Fermi surface nesting.

In this talk, using angle-resolved photoemission spectroscopy measurements, I will present evidence that show that instead of Fermi surface topology, strong electron correlation is an important ingredient for superconductivity in the iron chalcogenides. Specifically, I will show i) there exists universal strong orbital-selective renormalization effects and proximity to an orbital-selective Mott phase in $\text{Fe}_{1+y}\text{Te}_{1-x}\text{Se}_x$, $\text{A}_x\text{Fe}_{2-y}\text{Se}_2$, and monolayer FeSe film on SrTiO_3 [1,2], and ii) in $\text{Rb}_x\text{Fe}_2(\text{Se}_{1-z}\text{S}_z)_2$, where sulfur substitution for selenium continuously suppresses superconductivity down to zero, little change occurs in the Fermi surface topology, but a substantial reduction of electron correlation is observed in an expansion of the overall bandwidth, implying that electron correlation is the key tuning parameter for superconductivity in these materials.

[1] M. Yi et al. *Phys. Rev. Lett.* 110, 067003 (2013).

[2] M. Yi et al. *Nat. Comm.* 6, 7777 (2015).

[3] M. Yi et al. *arXiv*: 1505.06636.

Ming Yi works in experimental condensed matter physics, with an emphasis on strongly correlated electron systems. Her interest has been on the electronic and magnetic excitations of iron-based high temperature superconductors as measured using angle-resolved photoemission spectroscopy and neutron scattering. Specifically, Ming and her collaborators have studied the competing states to superconductivity in these materials, finding an orbital anisotropy as a manifestation of nematicity as observed in various iron pnictides. More recently, Ming and her collaborators have found and studied the orbital-selective Mott phase in the iron chalcogenide materials and established it to be of a universal behavior in various iron chalcogenide superconductors. Ming obtained her B.S. degree from the Massachusetts Institute of Technology in 2007, and her Ph.D. degree from Stanford University in 2014, both in physics. She is currently doing her postdoctoral works at the University of California, Berkeley, under the support of the 2015 L'Oréal For Women in Science Fellowship.



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Antiferroquadrupolar and Ising-nematic orders of a frustrated bilinear-biquadratic Heisenberg model and implications for the magnetism of FeSe

Motivated by the properties of the iron chalcogenides, we study the phase diagram of a generalized Heisenberg model with frustrated bilinear-biquadratic interactions on a square lattice. We identify zero-temperature phases with antiferroquadrupolar and Ising-nematic orders. The effects of quantum fluctuations and interlayer couplings are analyzed. We propose the Ising-nematic order as underlying the structural phase transition observed in the normal state of FeSe, and discuss the role of the Goldstone modes of the antiferroquadrupolar order for the dipolar magnetic fluctuations in this system. Our results provide a considerably broadened perspective on the overall magnetic phase diagram of the iron chalcogenides and pnictides, and are amenable to tests by new experiments.

[1] R. Yu and Q. Si, *Phys. Rev. Lett.* 115, 116401 (2015)

Rong Yu obtained his B.S. degree from Peking University in 1998, M.S. degree from Tsinghua University in 2001, and Ph.D. degree from University of Southern California in 2007. He was a postdoctoral research associate at University of Tennessee, Knoxville (2007–2009) and at Rice University (2009–2013). Since 2013 he has been an associate professor at Department of Physics, Remin University of China. He has been working on theory of correlated electronic systems. Current main areas of his research includes phase transitions in heavy fermion systems, frustration and disorder effects in quantum magnets, superconductivity and correlation effects in iron-based superconductors.



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Fermi surface reconstruction and multiple quantum phase transition in CeRhIn₅

CeRhIn₅ provides a prototype compound for studying quantum criticality and its interplay with superconductivity. Application of pressure suppresses the antiferromagnetic (AF) order and gives rise to superconductivity [1]. A sharp change of Fermi surface was observed just at the pressure-tuning AF quantum critical point (QCP) [2], which was argued to support the scenario of local quantum criticality[3]. By means of measuring the de Haas-van Alphen (dHvA) oscillations and specific heat in a pulsed magnetic field, we have recently demonstrated the existence of a field-induced AF QCP around $B_{c0} \approx 50\text{T}$ in this compound [4]. A sharp reconstruction of Fermi surface was observed well inside the AF state, i.e., around $B_0^* \approx 31\text{T}$, which might correspond to a localized-itinerant transition of Ce 4f-electrons attributed to the Kondo effect. These results suggest that multiple quantum phase transitions may exist in CeRhIn₅ which can be classified by the measurements of Fermi surface topology[4]. We further explored the multiple QCPs of CeRhIn₅ by mapping its pressure-magnetic field phase diagram with measurements of the Hall resistivity and magnetoresistivity under combined extreme conditions of high pressure and high magnetic field.

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LDA+DMFT approach to electronic correlation and magnetism in rare-earth free ferromagnets

The new challenges posed by the need of finding strong rare-earth free magnets demand methods that can predict magnetization and magnetocrystalline anisotropy energy (MAE). I will discuss the general status of electronic structure approaches to this problem. I will then argue that correlated electron effects, which are normally underestimated in band structure calculations, play a crucial role in the development of the orbital component of the magnetic moments. Because magnetic anisotropy arises from this orbital component, the ability to include correlation effects has profound consequences on our predictive power of the MAE of strong magnets. I will show that incorporating the local effects of electronic correlations with dynamical mean-field theory provides reliable estimates of the orbital moment, the mass enhancement and the MAE of YCo_5 [1]. I will also discuss the correlation effects and magnetism in Fe_3GeTe_2 [2].

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