北京大学量子材料科学中心
International Center for Quantum Materials, PKU

Seminar

Control of collective quantum phenomena in metal-oxide superlattices

Bernhard Keimer
Max Planck Institute for Solid State Research, Germany

Time: 10:00am, Nov. 24, 2014 (Monday)*
时间： 2014年11月24日 （周一）上午10:00*
Venue: Conference Room 607, Science Building 5
地点： 理科五号楼607会议室

**Note: there will be a total of three 30-min talks*

Abstract

A grand challenge in the field of correlated-electron physics is the transition from conceptual understanding of collective ordering phenomena to their control and design. We will outline recent results of an experimental program designed to meet this challenge through the synthesis and characterization of metal-oxide superlattices, with particular emphasis on copper and nickel oxides. We will show how spectroscopic methods such as resonant x-ray scattering, spectral ellipsometry, and Raman scattering can be combined to obtain a comprehensive description of the electron system in metal-oxide superlattices, and how the phase behavior of correlated electrons in these structures can be controlled by modifying the occupation of transition metal d-orbitals, the dimensionality of the electron system, and the electron-phonon interaction.

About the Speaker

Bernhard Keimer is currently Director at the Max Planck Institute for Solid State Research and Honorary Professor at the University of Stuttgart, Germany. He obtained his physics education from the Technical University of Munich and from the Massachusetts Institute of Technology, where he received his Ph.D. degree in 1991. Before taking up his current position in 1998, he spent seven years on the faculty of Princeton University, where he was appointed Full Professor in 1997. His research group uses spectroscopic methods to explore quantum many-body phenomena in correlated-electron materials and metal-oxide heterostructures. Bernhard Keimer has received numerous awards for his research, including most recently the Leibniz Prize of the German Science Foundation.

Seminar

Exotic electronic states produced by strong spin-orbit coupling in complex Ir oxides

Hidenori Takagi

Max Planck Institute for Solid State Research, Germany and Department of Physics, University of Tokyo, Japan

Abstract

In 5d Iridium oxides, a large spin-orbit coupling of ~0.5 eV, inherent to heavy 5d elements, is not small as compared with other relevant electronic parameters, including Coulomb U, transfer t and crystal field splitting D, which gives rise to a variety of exotic magnetic ground states. In the layered perovskite Sr_2IrO_4, spin-orbital Mott state with J_{eff}=1/2 is realized due to the novel interplay of those energy scales [1-3]. Despite the strong entanglement of spin and orbital degrees of freedom, J_{eff}=1/2 iso-spins in Sr_2IrO_4 was found to be surprisingly isotropic, very likely due to a super-exchange coupling through almost 180° Ir-O-Ir bonds [4]. The temperature dependence of in-plane magnetic correlation length of J_{eff}=1/2 iso-spins, obtained from inelastic x-ray resonant magnetic scattering, was indeed well described by that expected for two-dimensional S=1/2 Heisenberg antiferromagnet [4]. Such J_{eff}=1/2 2D Heisenberg magnet was recently shown to be tailored using $SrIrO_3/SrTiO_3$ super-lattice structure [5].

When J_{eff}=1/2 iso-spins interact with each other through 90° Ir-O-Ir bonds, very anisotropic bond dependent ferromagnetic coupling is expected, unique to strong SOC system. Complex Ir oxides with honeycomb and more recently identified *hyper-honeycomb* lattices [7], where x-, y- and z- 90° Ir-O-Ir bonds are realized, may be candidates for quantum spin liquid expected for the Kiatev model. Very likely due to the superposition of additional magnetic couplings not included in the Kitaev model [8], in reality, a long range magnetic ordering emerges at low temperatures in those compounds. Hyper-honeycomb b-Li_2IrO_3, though eventually show a marginal ordering, appears to be located at the critical vicinity to the Kitaev spin liquid.

In this talk, we focus on those exotic magnetisms in complex Ir oxides.

[1] B. J. Kim *et al.*, *Phys. Rev. Lett.* **101**, 076402 (2008).
[2] B. J. Kim *et al.*, *Science* **323**, 1329 (2009).
[3] S.Fujiyama *et al.*, *Phys. Rev. Lett.* **112**, 016405 (2014).
[4] G. Jackeli and G. Khaliullin, *Phys. Rev. Lett.* **102**, 017205 (2009).
[5] S. Fujiyama *et al.*, *Phys. Rev. Lett.* **108**, 247212 (2012).
[6] J. Matsuno *et al.*, submitted.
[7] T.Takayama, A. Kato *et al.*, submitted.
[8) A. Kitaev, *Annals of Physics* **312**, 2 (2006).

About the Speaker

Hidenori TAKAGI, born on March 20, 1961 in Tokyo, is a Director and Scientific Member of the Max Planck Institute for Solid State Research in Stuttgart, a Professor of Physics at the University of Tokyo and a professor at Institute for functional material and quantum technology at the University of Stuttgart. He studied Applied Physics at the University of Tokyo, where he received his PhD in 1989. After joining AT&T Bell Laboratories as a Post-Doctoral member of technical staff in 1990, he returned to the University of Tokyo, becoming an Associate Professor in 1994 and a Professor in 1999. In 2002, he was jointly appointed at RIKEN, Japan as a Chief Scientist and Group Director. In 2013, he became a Director of the Max Planck Institute for Solid State Research. His research interests include the metal-insulator transition, superconductivity, and quantum magnetism in correlated transition metal oxides. He received the IBM science prize (1988), Nissan science prize (1994), K. H. Onnes prize (2006), Honda Frontier Award (2009), and is a Fellow of the American Physical Society. In 2013 he was appointed Alexander von Humboldt Professor jointly at University of Stuttgart and Max Planck Institute for solid state research.

Seminar

Novel Josephson effect with triplet superconductors

Dirk Manske
Max Planck Institute for Solid State Research, Germany

Abstract

Novel Josephson junctions with triplet superconductors and magnetic tunneling barriers provide an excellent opportunity to observe the interplay of ferromagnetism and superconductivity in a controlled setting. In the theoretical study of Josephson junctions, it is usually assumed that the properties of the tunneling barrier are fixed.

This assumption breaks down when considering tunneling between two triplet superconductors with misaligned d-vectors in a TFT-junction (triplet–ferromagnet–triplet). Such a situation breaks time-reversal symmetry, which radically alters the behaviour of the junction, stabilizing it in a fractional state, i.e. the free energy minimum lies at a phase difference intermediate between 0 and π. Fractional flux quanta are then permitted at the junction. A further consequence of the d-vector misalignment is the appearance of a Josephson spin current. Recent experimental progress allows to fabricate thin films of the triplet superconductor Sr2RuO4 which opens the route for these new devices and possibly also for superspintronics.

About the Speaker

Dirk Manske is currently permanent staff scientist and group leader at the Max Planck Institute for Solid State Research and Adjunct Professor for Theoretical Physics at the Free University of Berlin, Germany. He obtained his physics education at the University of Hamburg, where he received a PhD (Dr. rer. nat.) in Theoretical Physics in 1997. Before taking his position at the MPI, he spend one year at the ETH Zuerich and 5 years at the Free University of Berlin where he received his Habilitation in 2003. His research group at the MPI focused on the Theory of Correlated Electron Systems, in particular Theory of Superconductivity in Novel and Complex Systems. Last year he won a competition and became also Visiting Professor at the Yukawa Institute for Theoretical Physics, Kyoto University, Japan. Dirk Manske has also written a book on 'Theory of Unconventional Superconductivity' (Springer, published 2004).