TT 13: Symposium "Superconductivity and Magnetism in Lamellar Cobaltates"

Time: Tuesday 14:00–17:50 Location: H18

Invited Talk TT 13.1 Tue 14:00 H18

Angle-resolved photoemission studies on Na_xCoO_2 — •Hong Ding — Boston College, Chestnut Hill, MA, USA

In this talk I will report a systematic angle-resolved photoemission study of Na_xCoO_2 single crystals for a wide range of Na concentrations. We observed a large Fermi surface centered at the Γ point, which satisfies Luttinger counting theorem when x ¡ 0.75. The small Fermi surface pockets predicted by LDA band calculations near the K points are not observed. Instead, "sinking islands"with the binding energy of 50 - 200 meV are observed. All of these, along with a large band renormalization, may be caused by the strong correlations in this material. In addition, at x = 1/3 where superconductivity occurs with proper water intercalation, we found that the large Fermi surface coincides with the new zone boundary of a commensurate charge ordering, suggesting that the charge fluctuations may play an important role in the superconductivity of this material.

Invited Talk TT 13.2 Tue 14:30 H18

Phase diagram and in-plane spin fluctuation in the novel superconducting system Na_xCoO_2 * y H_2O — •Kazuyoshi Yoshimura — Department of Chemistry, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan

Recent studies on the physical and chemical properties of the bilayer hydrated (BLH) triangular lattice superconductor Na_xCoO_2 * y H_2O have revealed the fact that the superconductivity would occur near the ferromagnetic electron correlations. We newly synthesized the non-superconducting and superconducting BLH Na_xCoO_2 * y H_2O compounds by the systematic sample preparation with time-controlling duration effect in high humidity atmosphere. As a result, we succeeded in constructing the electronic phase diagram as a function of the ^{59}Co NQR frequency, and found that superconducting phase exists very closely to the non-superconducting magnetic BLH phase in the vicinity of quantum critical point of magnetic correlations. These results strongly suggests that the superconductivity in BLH Na_xCoO_2 * y H_2O originates from the ferromagnetic fluctuation within the CoO_2 layer. This result is also supported by the results of $1/T_1$ of ^{23}Na NMR which can be explained by a part of the A-type fluctuations observed in the mother compound Na_xCoO_2. We will give a review of the physical and chemical properties of the exotic and anisotropic superconducting BLH compound, Na_xCoO_2 * y H_2O.

This work was done as collaborations with Hiroto Ohta, Chishiro Michioka, Yutaka Itoh, Yoshihiko Ihara and Kenji Ishida from Kyoto University.

TT 13.3 Tue 15:00 H18

Cooper-pair symmetry and spin correlations in the cobaltate superconductors Na_xCoO_2 * 1.3 H_2O — •Guo-qing Zheng — Okayama University, Okayama 700-8530, Japan

We will present NMR/NQR results on the symmetry of the Cooper pairs in the superconducting state and the spin correlations in the normal state of Na_xCoO_2 * 1.3 H_2O. We find that below T_c the spin-lattice relaxation rate ($1/T_1$), decreases in proportion to T^3 and down to very low temperature, strongly suggesting line nodes in the gap function [1,2]. The spin susceptibility measured via the Knight shift decreases below T_c in all directions [3]. These results indicate anisotropic, spin-singlet, (e.g., d-wave), pairing. In the normal state, the data point to antiferromagnetic spin correlations in the CoO_2 plane. We will also discuss the Na-content and pressure dependencies of the spin correlations and the superdconducting properties. This work was done in collaboration with K. Matano (Okayama U), R.L. Meng, J. Cmaidalka, C.W. Chu (Houston U), D.P. Chen and C.T. Lin (Max Plank Institute, Stuttgart).

[1] T. Fujimoto et al, Phys. Rev. Lett. 92, 047004 (2004). [2] G. - q. Zheng et al, J. Phys.: Condens. Matter 18, L63 (2006). [3] G. - q. Zheng et al, Phys. Rev. B73, 180503 (R) (2006).

15 min. break

TT 13.4 Tue 15:40 H18

Magnetic phase separation in highly Na doped Na_xCoO_2 with x > 0.75. — •Christian Bernhard[1], Li Yu[1], Alexander Boris[2], Dapeng Chen[2], Chengtian Lin[2], Bernhard Keimer[2], and Christof Niedermayer[3] — [1]Universität Fribourg, Chemin du Musee 3, CH-1700 Fribourg, Switzerland — [2]Max-Planck-Insitut für Festkörperforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany — [3]Paul-Scherrer-Institut, CH-5232 Villigen-PSI, Switzerland

We report muon spin rotation and infrared ellipsometry measurements on Na_xCoO_2 single crystals with 0.75<x<1 that provide evidence for an intrinsic phase separation scenario. At the highest Na content of x=0.97 we observe isolated magnetic clusters which have a small total spin of about S=1 and undergo a spin freezing transition around $T_{sf} \sim 20$ K. With decreasing Na content the cluster begin to overlap developing extended antiferromagnetic patches with T_N=22 K. A bulk long-range ordered state occurs near x=0.75. The optical data establish a highly anomalous charge transport with signatures of a strong spin charge coupling which is explained in terms of a hole doping induced spin state transition of the Co^{3+} ions.

TT 13.5 Tue 16:05 H18

Magnetic properties of spin-orbital polarons in lightly doped cobaltates — •Maria Daghofer, Peter Horsch, and Giniyat Khaliullin — MPI for Solid State Research, Stuttgart, Germany

We present a numerical treatment of a spin-orbital polaron model for Na_xCoO_2 at small hole concentration ($0.7 < x < 1$). We demonstrate how the polarons account for the peculiar magnetic properties of this layered compound: They explain the large susceptibility; their internal degrees of freedom lead both to a negative Curie-Weiss temperature and yet to a ferromagnetic intra-layer interaction, thereby resolving a puzzling contradiction between these observations. We make specific predictions on the momentum and energy location of excitations resulting from the internal degrees of freedom of the polaron, and discuss their impact on spin-wave damping.

TT 13.6 Tue 16:30 H18

Magnetic ordering and excitations in Na_xCoO_2 — •Sibel Bayrakci[1], Isabelle Mirebeau[2], Philippe Bourges[2], Yvan Sidis[2], Mechthild Enderle[3], Joel Mesot[4], Dapeng Chen[1], Chengtian Lin[1], and Bernhard Keimer[1] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart — [2]Laboratoire Léon Brillouin, C.E.A./C.N.R.S., Gif-sur-Yvette, France — [3]Institut Laue-Langevin, Grenoble, France — [4]Laboratory for Neutron Scattering, ETH Zurich & Paul Scherrer Institute, Villigen, Switzerland

Superconductivity in the layered cobalt oxide $Na_xCoO_2{:}yH_2O$ ($x \sim 0.30$, $y \sim 1.4$) is the subject of intensive current investigation. This material is particularly interesting given its structural similarity to the high-T_c copper oxide superconductors, with the added attribute of triangular symmetry. The unhydrated parent compound Na_xCoO_2 is itself intriguing due to its exceptionally high thermopower over the range $0.5 \leq x \leq 0.9$, which occurs in unusual combination with low resistivity and low thermal conductivity. Na_xCoO_2 has been shown to exhibit bulk antiferromagnetic order below ~ 20 K for $0.75 \leq x \leq 0.9$. In neutron scattering experiments on the composition with $x = 0.82$, we have observed Bragg reflections which correspond to A-type antiferromagnetic order and characterized the corresponding three-dimensional spin wave dispersion. The in- and out-of-plane exchange constants resulting from a fit to a simple Heisenberg model are similar in magnitude, which is unexpected given the layered crystal structure of Na_xCoO_2. Possible explanations will be discussed. Recent inelastic measurements on the $x = 0.5$ composition will also be mentioned.

15 min. break

TT 13.7 Tue 17:10 H18

Superconducting epitaxial thin films of $Na_xCoO_2 \cdot yD_2O$: A route to new experiments — Yoshiharu Krockenberger[1,2], Ingo Fritsch[2], Philipp Komissinskiy[1], Georg Christiani[2], Hanns-Ulrich Habermeier[2], and •Lambert Alff[1] — [1]Institute for Materials Science, TU Darmstadt — [2]Max-Planck-Institute for Solid State Research, Stuttgart

We report on the fabrication of epitaxial thin films of sodium cobaltate [1] and describe a way how to intercalate water in these films in order to obtain superconductivity [2]. The epitaxial thin films are

grown using pulsed laser deposition. We suggest a growth model for the hexagonal layered sodium cobaltate on the square lattice of the $SrTiO_3$ substrates. While these results are in themselves an achievement of advanced thin film technology, the availability of epitaxial thin films opens the way for improved and new experiments with $Na_xCoO_2 \cdot yD_2O$. While improved surface quality enhances the possibility of surface sensitive measurements, thin films also allow for the fabrication of Josphson and tunnel junctions to study the superconducting order parameter.

These work is supported by the Deutsche Forschungsgemeinschaft (project Al560/6).

[1] Y. Krockenberger, I. Fritsch, G. Christiani, A. Matveev, L. Alff, H.-U. Habermeier, and B. Keimer, Appl. Phys. Lett. **86**, 191913 (2005).

[2] Y. Krockenberger, I. Fritsch, G. Christiani, H.-U. Habermeier, Li Yu, C. Bernhard, B. Keimer, and L. Alff, Appl. Phys. Lett. **88**, 162501 (2006).

TT 13.8 Tue 17:35 H18

Electronic theory for itinerant in-plane magnetic fluctuations and many-body correlations in Na_xCoO_2 — •Maxim Korshunov[1,2], Ilya Eremin[1,3], Alexey Shorikov[4], and Vladimir Anisimov[4] — [1]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden, Germany — [2]L.V. Kirensky Institute of Physics, Siberian Branch of Russian Academy of Sciences, 660036 Krasnoyarsk, Russia — [3]Institute für Mathematische und Theoretische Physik, TU Braunschweig, 38106 Braunschweig, Germany — [4]Institute of Metal Physics, Russian Academy of Sciences-Ural Division, 620041 Yekaterinburg GSP-170, Russia

Based on the *ab-initio* band structure for $Na_xCoO_2 \cdot yH_2O$ we derive the single-electron energies and the effective tight-binding description for the t_{2g} bands using projection procedure. Due to the presence of the next-nearest-neighbor hoppings a local minimum in the electronic dispersion close to the Γ point of the first Brillouin zone forms. Correspondingly, in addition to a large Fermi surface an electron pocket close to the Γ point emerges at high doping concentrations. The latter yields the new scattering channel resulting in a peak structure of the itinerant magnetic susceptibility at small momenta. This indicates dominant itinerant in-plane ferromagnetic fluctuations above certain critical concentration x_m, in agreement with neutron scattering data. Below x_m the magnetic susceptibility shows a tendency towards the antiferromagnetic fluctuations. We further analyze the many-body effects on the electronic and magnetic excitations using various approximations applicable for different U/t ratio.