TT 7: Focused Session: Resonant Inelastic X-ray Scattering on Magnetic Excitations

Time: Monday 15:00–18:40 Location: H 0104

Invited Talk TT 7.1 Mon 15:00 H 0104

RIXS Studies of Strongly Correlated Electron Systems — •John Hill — Dept. of Condensed Matter Physics and Materials Science, Brookhaven National Laboratory, USA

Resonant Inelastic X-ray Scattering (RIXS) has undergone enormous theoretical and experimental development in recent years - to the point where the technique is now able to observe all the relevant low energy excitations, including phonons, magnons, orbital excitations, charge transfer excitations, etc. As a result it is now able to make significant contributions to many of the current hardest problems in condensed matter physics. Here I provide an overview of the technique, and its development, focusing on the hard x-ray regime. In particular, I review work on the cuprates, the observation of two-magnon scattering and the very recent work on the low energy excitations of the iridates including the observation of mixed spin and orbital excitations. Finally I conclude with a brief discussion of the exciting prospects for the future of this technique.

Invited Talk TT 7.2 Mon 15:40 H 0104

RIXS in the soft X-ray range: applications and perspectives — •Lucio Braicovich — Dip. di Fisica, Politecnico Milano 20133 Italy

After a brief introduction some recent results on RIXS in the soft x-ray range will be presented. The aim is to show the possibilities of the method and to explore the future growth areas. In particular we will discuss: (i) The measurement of the dispersion of magnons in undoped and in doped cuprates, (ii) the study of stripes in high Tc superconductors, (iii) the study of phonons, (iv) the measurement of the polarization of the radiation scattered by the sample, and (v) the peculiar aspects of RIXS at the FEL sources.

Finally we will present the RIXS project at the new soft x-rays beamline under consruction at the ESRF-Grenoble.

20 min. break.

Topical Talk TT 7.3 Mon 16:40 H 0104

The theory of resonant inelastic x-ray scattering on valence excitations — •Michel van Veenendaal — Department of Physics, Northern Illinois University, De Kalb IL 60115, USA — Argonne National Laboratory, 9700 S Cass Avenue, Argonne IL 60439, USA

The coupling between resonant inelastic x-ray scattering (RIXS) and valence excitations is discussed. The concepts of direct and indirect RIXS are described setting the framework for the interpretation of the RIXS cross section. The various mechanism how RIXS couples to dd-transitions, (bi)magnon excitations and phonons are discussed. It is shown how RIXS couples to the dynamic structure factor at the K-edge. At the L-edge, RIXS can be expressed in terms of effective transition operators drawing parallels to optical spectroscopy. Furthermore, selection rules in RIXS are discussed. Finally, the promise of RIXS in the future is discussed, in particular, in connection with X-ray free-electron lasers.

Topical Talk TT 7.4 Mon 17:20 H 0104

Excitons as a probe for low-energy spin fluctuations in cuprate chains — •Jochen Geck[1], Valentina Bisogni[1], Claude Monney[2], Kejin Zhou[2], Roberto Kraus[1], Jiri Malek[1], Stefan-Ludwig Drechsler[1], and Thorsten Schmitt[2] — [1]Leibniz Institute for Solid State and Materials Research, Dresden, Germany — [2]Paul Scherrer Institute, Villigen, Switzerland

High-resolution RIXS provides outstanding capabilities for studying the spin, charge and orbital dynamics in correlated electron materials. Focussing on one-dimensional cuprates, a short overview of recent experiments will be presented, which illustrates that soft RIXS is a unique probe for collective spin and orbital excitations in such systems. However, low-energy excitations below 10meV are currently not directly accessible with this technique, due to the limited energy resolution of about 100meV. In this talk, we will present an experimental approach that circumvents this limitation. Using a charge transfer exciton as a probe, we show that local spin fluctuations at excitation energies of the order of 1meV can be detected with great sensitivity. Two prototypical edge-sharing cuprate chain materials with different magnetic intra-chain order have been studied in this way, namely $CuGeO_3$ (AFM) and Li_2CuO_2 (FM). For the latter, the FM intra-chain spin order is confirmed, but strong AFM spin fluctuations are still observed well below the magnetic ordering temperature. This reveals that Li_2CuO_2 is close to a quantum critical point. The presented method provides an excellent tool to characterize new one-dimensional cuprate materials and to search for novel magnetic ground states.

Topical Talk TT 7.5 Mon 18:00 H 0104

Fractionalization of electronic degrees of freedom in low-dimensional cuprates — •Justine Schlappa[1,2], Thorsten Schmitt[1], Kejin Zhou[1], Krzysztof Wohlfeld[3], Jeroen van den Brink[3], Maurits Haverkort[4], Martin Mourigal[5], and Henrik Rønnow[5] — [1]Paul Scherrer Institut, Swiss Light Source, CH-5232 Villigen PSI, Switzerland — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, D-12489 Berlin, Germany — [3]Leibniz Institute for Solid State and Materials Research IFW Dresden, D-01171 Dresden, Germany — [4]Max Planck Institute for Solid State Research, D-70569 Stuttgart, Germany — [5]Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland

Quantum effects become important, when the space symmetry is lowered. In the extreme case of one dimension the fundamental degrees of freedom of the electron can break up into separate quasi-particles, carrying either one of the spin, charge or orbital degrees of freedom. Here we report the study of elementary excitations in the quasi 1D cuprate Sr_2CuO_3, using high-resolution Resonant Inelastic X-ray Scattering. In the low-energy range the fractionalization of magnons into two-spinons and higher order excitations is observed, as previously reported from neutron scattering [1]. At higher energies we observe the deconfinement of spin and orbital degrees of freedom [2]. This phenomenon allows for the first time a direct observation of strongly dispersive orbital excitations (orbitons).

[1] A.C. Walters et al., Nature Physics 5, 867 (2009).
[2] J. Schlappa, T. Schmitt et al., submitted