The European Physics Society
2018 EPS Condensed Matter Division Europhysics Prize
Long Citation

The 2018 EPS Condensed Matter Division Europhysics Prize is awarded to Lucio Braicovich and Giacomo Ghiringhelli for the development and scientific exploration of high-resolution Resonant Inelastic X-ray Scattering (RIXS). The Prize will be presented on Tuesday March 13th, 2018, at the Awards Session of the 27th General Conference of the EPS Condensed Matter Division, to be held in Berlin from 11 to 16 March 2018 together with the Spring Meeting of the Condensed Matter Division of the German Physical Society DPG.

The foundation of the “RIXS revolution” was laid in the 1990’s, when Lucio Braicovich with Claudia Dallera and Giacomo Ghiringhelli designed the Advanced X-ray Emission Spectrometer (AXES) and installed it at the European Synchrotron Radiation Facility (ERSF) together with ESRF staff scientist Nick Brookes. The modular design of AXES allowed them to systematically enhance resolution by implementing new components and improving their alignment over time. By 2002, the attained resolution of 0.5-0.8 eV allowed unprecedented momentum- and polarization-dependent studies of crystal-field excitations in Mott-insulating manganates, nickelates, and cuprates with photons at the *L*- and *M*-absorption edges of the transition metal ions.

Braicovich and Ghiringhelli then designed and constructed the Super-AXES (SAXES) spectrometer, installed at the Swiss Light Source in collaboration with staff scientists Thorsten Schmitt and others in 2006. The ensuing improvement of the spectral resolution to ~ 0.1 eV led to the discovery of a dispersive excitation branch in the high temperature superconducting cuprates, with behaviour identical to that of spin waves previously studied by neutron scattering. The observation proved that single-magnon excitations are accessible to RIXS. In further experiments on doped La_2CuO_4, Braicovich and Ghiringhelli confirmed the theoretically predicted polarization dependence for spin-flip excitations of the valence electrons due to strong spin-orbit coupling, at the base of the observation of single magnons in RIXS. They then mapped out the magnetic excitation spectrum, with greatly enhanced cross-section and sensitivity to high-energy excitations compared to previous studies.

The discoveries made using RIXS have fundamentally changed the discourse on the electronic structure of the cuprates. Notably, Braicovich and Ghiringhelli and their collaborators showed that dispersive high-energy spin excitations may persist well into the cuprates’ overdoped regime. The greatly enhanced sensitivity of the SAXES spectrometer was crucial in the discovery of a charge density wave (CDW) phase in moderately doped cuprates. High-resolution RIXS was also used to detect momentum-dependent, collective orbital excitations (“orbitons”) in cuprates, titanates, and vanadates. The possibility to directly address orbital degrees of freedom is truly groundbreaking, and represents a qualitative advance over prior experiments that had probed these excitations at zero momentum transfer.

Recently, Braicovich and Ghiringhelli (again with Nick Brookes) have commissioned the ERIXS spectrometer at the ESRF, and have conducted the first experiments that take advantage of its unprecedented resolution of 0.03 eV (at the Cu L-absorption edge). These concern detailed, quantitative comparisons of magnon dispersions in different families of cuprates; the measurement of phonons and the electron-phonon interaction; and the discovery of collective modes of charge density waves.

The advantages of the RIXS technique – measurement of the entire Brillouin zone, unprecedented energy resolution, applicability to small sample volumes under extreme conditions – have led to advances and discoveries inconceivable just a few years ago, that have transformed the landscape of solid-state spectroscopy, inspired a new generation of scientists now entering the field, and will continue to very significantly impact condensed matter research in the years to come. This revolutionary development is due to the vision, the commitment, and the determination of Lucio Braicovich and Giacomo Ghiringhelli, who conceived and worked on high resolution RIXS with great determination for well over a decade, have pioneered the development of both key hardware and scientific concepts, and performed crucial experiments.