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Two-dimensional-ARPES by momentum microscopy (M.M.) and resonance inelastic soft X-ray scattering (SXRIXS)

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High energy spectroscopy ($h\nu$<10 keV) is now in a revolutionary phase. In the case of ARPES, two orders of magnitude higher detection efficiency is realized by use of a momentum microscope (M.M.) composed of a PEEM type input lens and an aberration-suppressed tandem hemispherical deflection analyzers (HDAs). High resolutions can be achieved for $\Delta k_x,\Delta k_y$ and ΔE_B. High detection efficiency is based on the full 2π steradian acceptance of photoelectrons and simultaneous (k_x,k_y) detections at 100x100 to 200x200 points up to 2^{nd}, 3^{rd} Brillouin zones (BZs). Relative intensities at all (k_x,k_y) points are uniquely determined in contrast to the conventional 2D ARPES by a single HDA, where the sample must be rotated to cover a wide (k_x,k_y) region. Experimental results can be compared with advanced theories up to the details including faint ARPES structures.

In contrast to rather surface sensitive ARPES for metals and semiconductors, studies of electronic structures of thousands of insulators are much behind. It is widely known that photon spectroscopy is applicable to any insulators. Bulk information is available through photon spectroscopy, where various external perturbations can also be used.

We have recently performed SXRIXS on various transition metal oxides. In the case of a CrO_2 thin film, which is a ferromagnetic metal covered by AF insulator Cr_2O_3 surface layer, ARPES could not reveal reliable electronic structures. We could, however, reveal bulk SXRIXS spectrum of CrO_2 by comparing the results with that of bulk Cr_2O_3. We observed clear circular dichroism of CrO_2 in an external magnetic field. Since the $h\nu$ resolution can be much improved in the SX region down to 10 meV in the near future, SXRIXS studies of **H, E**, as well as uniaxial stress effects will be very interesting in the near future.