Imaging surfaces using the photoemission electron microscope

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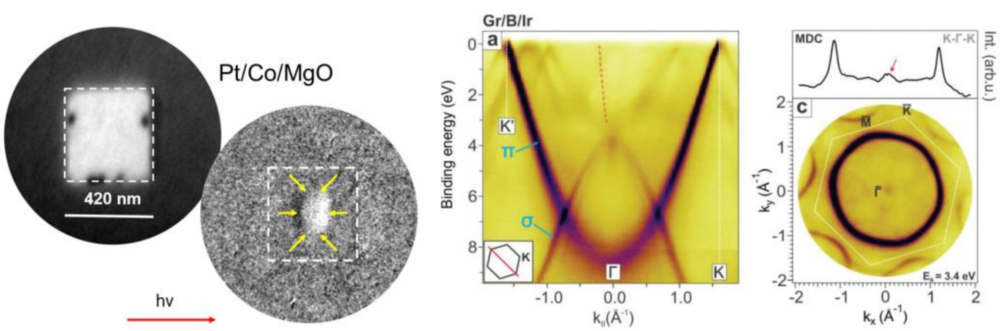
The photoemission electron microscope (PEEM) was invented in the early 1930s by German physicist Ernst Brüche, who first demonstrated that photoelectrons emitted from a cathode illuminated with UV light could be used for imaging. Since then, PEEM has evolved enormously, thanks to multiple advances in electron optics and ultra-high vacuum technology. The success of PEEM at synchrotron facilities started in the '90s, following the advent of undulator sources providing very intense and tunable photon beams in the energy range from UV to soft X-rays. Today, all European synchrotrons have at least one beamline hosting a PEEM end-station, making it possible to perform absorption or photoemission spectroscopy at high lateral resolution.

In my lecture I will introduce the basics of the PEEM methodology. The multi-modal capability of modern instruments operating at synchrotrons, enabling sensitivity to both the chemical and magnetic state of the specimen, will be highlighted. Real-space and diffraction imaging operations, as well as fast spectroscopy mode, will be illustrated by several examples. Emphasis will be placed on PEEM applications carried out at Elettra, using the microscope installed at the Nanospectroscopy beamline. Particular attention will be given to 2D materials and magnetism. Finally, the PEEM will be compared with competing techniques, SPEM and STXM, presenting their respective strengths and weaknesses. Current trends and future opportunities will be discussed.



From left to right. Co L_3 edge XAS-PEEM and XMCD-PEEM images of a Pt/Co/MgO nanostructure. The first image shows the lateral size of the Co square. The second image shows the magnetic fingerprint of a skyrmion, a non-trivial magnetic structure that has attracted huge scientific attention in the past years [1]; PEEM is ideally suited to perform microspot-ARPES measurements on layered materials: the example on the right hand side of the figure shows the electronic structure of Gr/B/Ir(111).

References:

[1] O. Boulle *et al*., Nat. Nanotech. **11**, 449–454 (2016).

[2] M. Jugovac et al., Adv. Elect. Mater. **9**, 2300136 (2023).