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High resolution photoemission on CASSIOPEE

The CASSIOPEE beamline offers two experimental branches, dedicated to spin-resolved photoemission and high resolution angle-resolved photoemission, respectively. To achieve high resolution, measurements have to be made at low temperatures.

Photoemission – or more precisely, photoelectron spectroscopy – is an analysis technique consisting in sending light with a sufficient energy (UV or X-ray) onto the sample atoms in order to provoke the emission of one or several electrons from these atoms. The kinetic energy of the ejected electrons, as well as their emission angle, provides information on the chemistry of the material under study as well as its physical properties.
As electrons cannot travel far in matter, photoemission is adapted to the study of surfaces – up to thicknesses of one or two nanometers. This requires working under ultra-high vacuum (10^{-8} to 10^{-10} mbar pressure) so as to limit the adsorption of polluting molecules (H_2O, O_2...) on the surface to be analyzed.

Why are low temperatures necessary?

Photoemission spectral lines broaden with temperature due to thermal agitation of the atoms. It is thus easy to understand the importance of working at low temperature to decrease the width of these lines, and therefore improve the resolution of the measurement. The CASSIOPEE research team have found a second advantage, linked to the subjects under study: the possibility to follow the evolution of a material's properties as a function of the temperature (metal/insulator transition for example), to evidence the changes in the electronic structure at the origin of this transition. For these reasons, a first sample holder was designed to equip CASSIOPEE for high resolution angle-resolved photoemission spectroscopy (HR-ARPES). This work was carried out in collaboration with Véronique Brouet, Gilles Guillier and Alessandro Nicolaou (Laboratoire de Physique des Solides, Orsay).

Daniel Ragonnet and Patrick Le Fèvre, of the CASSIOPEE beamline, working on the new cryostat sample holder.

A first tool for a cooling down to 5K

A liquid helium cryostat, which allows the sample to be cooled down to 5K, has been installed in the experiment under ultra-high vacuum. The sample placed on this holder can be rotated around the vertical axis, while the electron analyzer permits the angular analysis in a 30° range in the vertical direction. By combining these two detection angles, the electrons emitted by the sample can be detected in a large solid angle.
Since 2008, a large number of users have benefited from the very low temperatures offered by this sample holder, notably to study the conductor/superconductor transition of several materials.
However, the CASSIOPEE team wanted to broaden the HR-ARPES field, limited mainly by the lack of degrees of freedom of the sample holder.

A second three-rotation sample holder

Experiments requiring wider angular ranges were not possible with the first sample holder and its unique rotational axis, which, in addition, was not automated. The Axess Tech Company has been approached to design a second sample holder, which will be operational in mid 2010.
Completely automated, with three rotations, it will complete the HR-ARPES branch by making it possible to carry out, for example, photodiffraction experiments. In March, during first tests, it was possible to record a temperature of 25K on the sample.
Users are already impatient to use this tool for studies on thin layers of iron oxides with promising properties in the field of spintronics.

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