AN EXPERIMENTAL COMPARISON OF FIRST, SECOND AND THIRD GENERATION SYNCHROTRON - RADIATION SOURCES FOR GAS-PHASE PHOTOELECTRON SPECTROMETRY

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Synchrotron radiation (SR) emitted by undulator sources in the straight section of dedicated electron/positron storage rings is the brightest source of photon beams continuously tunable over the VUV and X ray energy regions. Introduced during the late 70's, these insertion devices are used as research tools on second-generation storage rings. Third generation SR sources are now being built to accommodate as many undulator beam lines as possible.
One of the main characteristics of third-generation storage rings is very low emittance of the electron/positron beams, providing photon beams of unprecedented spectral resolution. However, having a high-precision undulator installed on a straight section of a third-generation storage ring is not sufficient; it is also necessary to have available a beamline and a monochromator with excellent optics well matched to the new properties of the synchrotron source.
We had the opportunity, over the past years, to utilize five different SR sources to investigate photoemission of xenon and lithium atoms in the gas phase, using basically the same experimental apparatus. We have obtained quantitative information on the performance of each of them, and, thus, we have been able to characterize progress made in the development of synchrotron-radiation sources.
The experimental apparatus consists of an electron analyzer, specifically a cylindrical mirror analyzer (CMA), a multicapillary array for introducing rare-gas beams into the source volume of the CMA or a resistively heated oven collinear to the axis of the CMA, and channeltron to detect the photoelectrons emitted at the magic angle with respect to the direction of the photon beam.
The five different SR sources were; a bending magnet beamline of the ACO storage ring in Orsay, used first with a Rowland circle monochromator , [1,2] then with a toroidal gratin monochromators (TGM), [3] the bending-magnet beamline SA23 of the SuperACO storage ring in Orsay, equipped with a 1.8 meter TGM,

the undulator beamline SU7 of Super ACO used with a 10 meter-TGM [4] and, last but not least, the undulator beamline 9.0.1 at the Advanced light Source equipped with a spherical grating monochromator.[5]

To summarize the main conclusion drawn from these measurements, the experimental conditions in which we were able to *routinely* run our photoelectron spectrometry experiments over the 90 eV-150 eV photon energy range improved continuously, from a spectral resolution of 1 eV with a photon flux of about 10^9 ph/sec, to 0.019 eV with 10^{12} ph/sec, respectively, illustrating the dramatic progress made for studying photoionization of atoms and molecules in the gas phase. These results demonstrate that a high-precision undulator installed on a third-generation storage ring in combination with excellent x-ray optics is able to provide high-resolution/high intensity monochromatic photon beams in the VUV and soft X-ray range, allowing a detailed test of the most advanced many-body atomic theories.

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