UVSOR Synchrotron Facility

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Outline of the UVSOR Synchrotron Facility

Since the first light in 1983, UVSOR Synchrotron Facility has been successfully operated as one of the major synchrotron light sources in Japan. After the major upgrade of the accelerators in 2003, UVSOR Synchrotron was renamed to UVSOR-II Synchrotron and became one of the world's brightest low energy synchrotron light sources. In 2012, it was upgraded again and has been renamed to be UVSOR-III Synchrotron. The brightness of the electron beam was increased further. Today, six undulators are installed in total, and the storage ring is regularly operated in the top-up mode, in which the electron beam current is kept constant, irrespective of multi (16) bunches or single bunch.

The UVSOR accelerator complex consists of a 15 MeV injector linac, a 0.75 GeV booster synchrotron, and a 0.75 GeV storage ring. The magnet lattice of the storage ring consists of four extended double-bend cells with distributed dispersion function. The storage ring is normally operated under multi-bunch mode with partial filling. The single bunch top-up operation for time-resolved measurements or low current measurements is also conducted for two weeks per year.

Six undulators and eight bending magnets provide synchrotron radiation (SR). The bending magnet, its radius of 2.2 m, produces SR with the critical energy of 425 eV. There are eight bending magnet beamlines (BL1B–BL7B, and BL2A to be moved to BL8B). Three of the six undulators are in-vacuum soft X-ray (SX) linear-polarized undulators (BL3U, BL4U, BL6U) and the other three are vacuum/extreme ultraviolet (VUV/XUV or EUV) circular-polarized undulators (BL1U, BL5U, BL7U). In total, fourteen beamlines (= fourteen endstations) are now operating in two categories: Twelve are so-called "public beamlines," which are open to scientists from universities, governmental research institutes, public and private enterprises, and also to overseas scientists; the other two beamlines are so-called "in-house beamlines," which are dedicated to strategic projects conducted by internal IMS groups in tight collaboration with domestic and foreign scientists. From the viewpoint of photon energies, we have 1 SX station equipped with a double-crystal monochromator, 7 SX stations with a grazing incidence monochromator, 3 VUV stations with a normal incidence monochromator, 2 infrared/tera Hz stations equipped with Fourier transform interferometers and 1 beamline for light source development without any monochromators.

Figure 1. UVSOR-III electron storage ring, radiation shield wall, and beamlines/endstations.

Inter-University and International Collaboration Programs

A variety of molecular science and related subjects have been carried out at UVSOR Synchrotron by IMS and external/overseas researchers. The number of visiting researchers per year tops > 1200, who come from > 60 different institutes. International collaboration is also pursued actively, and the number of visiting foreign researchers reaches >100 from >10 countries. UVSOR-III Synchrotron invites new/continuing research proposals twice a year. The proposals both for academic and public research (charge-free) and for private enterprises (charged) are acceptable. The fruits of the research activities using UVSOR-III Synchrotron are published as the UVSOR ACTIVITY REPORT annually.

Recent Developments

BL6B is an Infrared-THz beamline which has confocal type micro-spectroscope station, reflection/transmission station, and IR microscope imaging station. To solve serious long term drift of beam path caused by M0 magic mirror thermal load, the feedback control system of M0 mirror angle by monitoring the reflection of visible laser light from M0 mirror has been developed. This feedback control system has been routinely operated and successfully provides stable beam for users from this year.

Reserch Highlights[1)]

Optical vortex has a helical wavefront and carries orbital angular momentum (OAM) as well as spin angular momentum associated with its circular polarization. Differing from plane-wave photons, violation of the standard electric dipole selection rules is predicted in an interaction between the optical vortex and an atom, as a consequence of the transference of the OAM to the internal degrees of freedom of the atom. The experiment on vortex-matter interactions in the VUV energy range was carried out for the first time, at the beamline BL1U. The VUV vortex beams at about 30 eV photon energy were produced by a helical undulator as the higher harmonics. Photoelectron angular distributions of helium atoms were measured by using a velocity map imaging spectrometer. Figure 1 shows the angular distributions measured for the first, second and third harmonics, corresponding to plane-wave photons ($l = 0$), and VUV vortices of $l = 1$ and 2, respectively. While the violation of the electric dipole transition rules has been predicted for interactions between vortices and atoms, the photoelectron angular distributions are well reproduced by the dipole components alone, and non-dipole contributions are not detected within the experimental uncertainty. This observation can be explained by the localized nature of the helical phase effect of the vortex on the interaction with atoms, and demonstrates that non-dipole interactions induced by vortex are hardly observable in conventional gas-phase experiments.

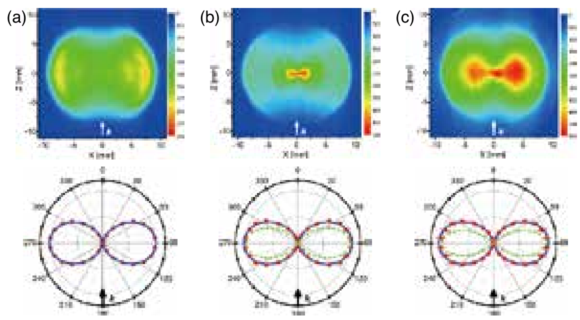

Figure 2. Photoelectron angular distributions of helium atoms measured for the (a) first, (b) second and (c) third harmonics from helical undulator. The solid blue curves represent fits assuming electric dipole transition. The dotted green curves in (b) and (c) show the angular dependence of the photoelectron expected for non-dipole transitions induced by the OAM carried by the VUV vortex.

Reference

1) T. Kaneyasu *et al.*, *Phys. Rev. A* **95**, 023413 (2017).