UVSOR Facility

IX-BB Development of the UVSOR Light Source

IX-BB-1 Successful Commissioning of UVSOR-II

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In 2003, UVSOR was successfully converted to a high brilliance synchrotron light source, UVSOR-II, which has eight straight sections and small emittance of 27 nm-rad. All the reconstruction works were completed within three months, from April to June 2003. The commissioning and the machine tuning were completed until the end of August. User experiments were started in September. The filling beam current is 350 mA. The light source is operated for 12 hours a day with an injection interval of 6 hours. Although a small beam emittance of 27 nm-rad was achieved in the machine studies, the light source is currently operated for users with a moderately small emittance of 60 nm-rad, which gives a longer beam lifetime. The low emittance operation for users will be started after the reinforcement of the RF accelerating system, which is planned in spring, 2005.

IX-BB-2 Commissioning of In-Vacuum Undulator for BL3U

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During the construction of UVSOR-II, an in-vacuum undulator was installed, whose period length was 38 mm and the number of the periods was 50. This undulator provides high brilliance soft X-rays to the newly constructed beam-line, BL3U. In the machine studies, it was confirmed that the storage ring could be operated with the small pole gap of 15 mm without reducing the beam lifetime. No beam instabilities, such as the resistive wall instability, were observed. The newly developed control system can correct the electron orbit shift due to the pole gap changes with a precision better than 10 microns. The users can change the pole gap and the photon energy at their experimental station anytime.

IX-BB-3 UVSOR Free Electron Laser

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The upgrade of UVSOR increased the brightness of the electron beam. The improved quality of the beam is of great advantage to the storage ring FEL. We expect increase of the FEL gain by about one order with the present FEL system. In December, 2003, we have succeeded in oscillating the FEL for the first time after the upgrade. We confirmed the increase of the FEL gain. To improve the performance of the FEL further and deliver shorter wavelength laser to user, we are designing a new FEL system, which includes a new in-vacuum optical klystron type undulator optimized to lasing in the deep UV and VUV region.

IX-CC Researches by the Use of UVSOR

IX-CC-1 Autoionization Selectivity of Ne^+ Rydberg States Converging to $Ne^{2+}(^1S^e)$

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[*J. Phys. B* **37**, 2823 (2004)]

Indirect double photoionization processes of Ne have been studied in the photon energy range from 65.5 to 68.3 eV by using a threshold-photoelectron-photoelectron coincidence method, where intermediately-formed Ne^+ states have been defined by the detection of threshold photoelectrons and fast electrons from their autoionizing decay have been analyzed in coincidence. The present investigation revealed that each Ne^+ Rydberg series converging to $Ne^{2+}(^1S^e)$ shows notable selectivity in the autoionizing decay to the final Ne^{2+} states.

IX-CC-2 Dissociative Double Photoionisation of CO below the CO^{++} Threshold

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[*Chem. Phys.* **299**, 147 (2004)]

Dissociative double photoionisation of CO below the adiabatic double ionisation threshold has been studied by the time-of-flight photoelectron-photoelectron coincidence (TOF-PEPECO) and the velocity imaging photoionisation coincidence (VIPCO) methods. By combining the results from the two methods which give complementary information, the double photoionisation process is identified to $CO + h\nu \rightarrow CO^{+}* + e^{-} \rightarrow C^{+}(^{2}P) + [O^{+}(^{2}D/^{2}P)]nl + e^{-} \rightarrow C^{+}(^{2}P) + O^{+}(^{4}S) + 2e^{-}$. The high energy resolution of the TOF-PEPECO spectrometer enables us to resolve individual fragment $[O^{+}(^{2}D/^{2}P)]nl$ states and also intermediate $CO^{+}*$ states. The angular correlations between electrons and ions, deduced from the VIPCO data, imply that the nuclear dissociation is faster or at least comparable in the time scale with molecular rotation, and that the second electron emission occurs after the C^{+} and O* atoms are far apart. A possible generic identification of the intermediate states is suggested.

IX-CC-3 Sub-Natural Linewidth Auger Electron Spectroscopy of the 2s Hole Decay in H_2S

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[*J. Electron Spectrosc. Relat. Phenom.* **137**, 287 (2004)]

Threshold photoelectron-Auger electron coincidence spectroscopy has been applied to the sulphur 2s region of H_2S, where the Auger electron spectrum is measured in coincidence with threshold electrons. Formation of $H_2S^{++}[(S2p)^{-1}(V)^{-1}]$ states *via* the $L_1L_{2,3}V$ Coster-Kronig transitions is observed above the S 2s photoionization threshold. Even below threshold, formation of these H_2S^{++} states is seen and is due to direct double ionization. A sub-natural linewidth regime is achieved with this coincidence method and three structures resulting from overlaps of the H_2S^{++} $[(S2p)^{-1}(V)^{-1}]$ states appear in the spectra. The three structures probably correspond to H_2S^{++} states with the $2b_1$, $5a_1$ and $2b_2$ holes.

IX-CC-4 Formation of Fluorescent and Metastable Fragments by Photoexcitation of Some Diatomic Molecules in the Vacuum Ultraviolet Region

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[*J. Phys. B* **37**, 283 (2004)]

The formation of fluorescent and metastable fragments from four diatomic molecules, *i.e.* O_2, N_2, NO and CO, has been investigated in the vacuum ultraviolet region. The neutral particles are detected by using a microchannel plate stack, where retarding electric potentials prevent charged particles from reaching the detector. Every diatomic molecule investigated here shows formation of fluorescent and metastable fragments in particular photon energy regions. Three Rydberg states of O_2 converging to $O_2^{+}(a^{4}\Pi_u)$ undergo both neutral dissociation processes forming fluorescent $[O^{+}(^{4}S)]3s\ ^{3}S_1$ and metastable $[O^{+}(^{4}S)]3s\ ^{5}S_2$, the yield curve for each fragment is determined. Direct and cascade formation of the fluorescent $[N^{+}(^{3}P)]3s\ ^{4}P$ fragment from N_2 are separated, and it is found that the dissociation of the 4sσ Rydberg state converging to $N_2^{+}(C^{2}\Sigma_u^{+})$ preferably produces $[N^{+}(^{3}P)]3p$ fragments, but not or weakly the $[N^{+}(^{3}P)]3s\ ^{4}P$ fragment. High-*n* Rydberg states converging to NO+($c^{3}\Pi$) and $CO^{+}(D^{2}\Pi)$ undergo neutral dissociation described by the core ion model, resulting in large peaks for neutral particle formation.

IX-CC-5 New Molecular Inner-Shell Spectroscopy for Probing Multiple Excitations

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[*AIP Conf. Proc.* **705**, 1118 (2004)]

A new experimental setup for probing multi-electron processes in molecular inner-shell ionization regions has been developed at the UVSOR facility, IMS. A zero-kinetic-energy electron (ZEKE) analyzer is composed of a lens system on the basis of the penetrating field technique and an electrostatic analyzer. Two identical ion detectors with regarding grids are utilized for detecting the fragment-ions emitted at 0 and 90 degrees relative to the electric vector of the light, which correspond to the symmetry-resolved photoabsorption spectra. The symmetry-resolved ZEKE spectra have been measured by scanning the photon energy with monitoring the intensity of the coincidence signals between the ZEKE electrons and fragment-ions. The results obtained using the new setup are reported.

IX-CC-6 Optical Conductivity of a Non-Fermi-Liquid Material $YbRh_2Si_2$

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[*J. Magn. Magn. Mater.* **272-276**, 36–37 (2004)]

The temperature-dependent electronic structure of a pronounced non-Fermi-liquid material $YbRh_2Si_2$ has been investigated by the optical conductivity measurement in the photon energy range of 10 meV–30 eV at several temperatures of 2.7–300 K: The optical conductivity spectrum as well as the electronic structure changes at two temperatures of 80 and 20 K: At 80 K;

the heavy quasiparticles develop and at 20 K; the non-Fermi liquid behavior appears in the optical conductivity spectra.

IX-CC-7 New Infrared and Terahertz Beamline BL6B at UVSOR

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[*AIP Conf. Proc.* **705**, 416–419 (2004)]

We have designed a new infrared beam line BL6B at UVSOR for infrared and terahertz spectroscopies including microspectroscopy with high brilliance and high flux. The beam line will be replaced in the spring of 2004 from the infrared beam line, BL6A1, at UVSOR. The beam line has a large acceptance angle of 215(H) × 80(V) mrad^2 and a so-called "magic mirror" is adopted to get the perfect focusing of the bending magnet radiation. The optics and expected performance (focus size, photon flux and brilliance) are reported.

IX-CC-8 Change of Electronic Structure Induced by Magnetic Transitions in CeBi

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[*J. Phys. Soc. Jpn.* **73**, 2041–2044 (2004)]

The temperature dependence of the electronic structure of CeBi arising from two types of antiferromagnetic transitions based on optical conductivity was observed. The optical conductivity spectrum continuously and discontinuously changes at 25 and 11 K, respectively. Between these temperatures, two peaks in the spectrum rapidly shift to the opposite energy sides as the temperature changes. Through a comparison with the band calculation as well as with the theoretical optical conductivity spectrum, this peak shift was explained by the energy shift of the Bi 6p band due to the mixing effect between the Ce 4f Γ_8 and Bi 6p states. The single-layer antiferromagnetic transition from the paramagnetic state was concluded to be of the second order. The marked changes in the optical conductivity spectrum at 11 K, however, indicated the change in the electronic structure was due to a first-order-like magnetic transition from a single-layer to a double-layer antiferromagnetic phase.

IX-CC-9 Para- to Antiferro-Magnetic Phase Transition of CeSb Studied by Ultrahigh-Resolution Angle-Resolved Photoemission Spectroscopy

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Temperature-dependent angle-resolved photoemission spectroscopy has been performed on CeSb to study the origin of its complicated magnetic phase transition. In the paramagnetic phase ($T \geq 30$ K), we have found that the electronic structure near the Fermi level (E_F) consists of the hole-like Sb 5p band at the Γ point and the electron-like Ce 5d bands at the X point. With decreasing temperature across Néel temperature (T_N = 10 K), both the energy shift and the energy splitting of the bands appear along the ΓX high-symmetry line. While the energy shift of the bands is consistent with the pf mixing model, the energy splitting has not been expected in the model so far. On the other hand, by comparing with the recent calculation based on the pf+dp mixing model, we found a qualitative agreement between the experiment and the calculation. This result suggests the importance of the dp mixing effect to interpret the mechanism of the magnetic phase transition of CeSb.

IX-CC-10 Optical Study on *c-f* Hybridization States in Mixed-Valent Yb Compounds: Metallic $YbAl_3$ *vs* Semiconducting YbB_{12}

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[*J. Magn. Magn. Mater.* **272-276**, e51–e52 (2004)]

We have measured the optical conductivity spectra of YbB_{12} and $YbAl_3$; which are typical mixed-valent Yb compounds. The measured optical conductivity spectra in the mid-infrared region are quite similar for the two compounds, with a pronounced peak centered near 0.2 eV: This result demonstrates that the Kondo semiconductor YbB_{12} and the highly metallic $YbAl_3$ share very similar electronic structures near the Fermi level, in spite of their very different transport properties at low temperatures. This observation is discussed in terms of *c–f* hybridization states in these compounds.

IX-CC-11 The Origin of the Phase Separation in Partially Deuterated κ-$(ET)_2Cu[N(CN)_2]Br$ Studied by Infrared Magneto-Optical Imaging Spectroscopy

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The direct observation of the phase separation between the metallic and insulating states of 75%-deuterated κ-$(ET)_2Cu[N(CN)_2]Br$ (d33) using infrared magneto-optical imaging spectroscopy is reported, as

well as the associated temperature, cooling rate, and magnetic field dependencies of the separation. The distribution of the center of spectral weight (<ω>) of d33 did not change under any of the conditions in which data were taken and was wider than that of the non-deuterated material. This result indicates that the inhomogenity of the sample itself is important as part of the origin of the metal - insulator phase separation.

IX-CC-12 Auger Electron Spectroscopy in Coincidence with Photoelectrons

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We have developed Auger-photoelectron coincidence spectroscopy, which involves measuring Auger electrons in coincidence with corresponding photoelectrons, to elucidate the decay dynamics of the inner-shell hole states followed by the production of doubly charged atomic and molecular ions. Two analyzers for the Auger electrons and photoelectrons have been installed in a vacuum chamber, and we have successfully obtained the first coincidence spectrum for OCS at BL4B in spring 2004. In our experiment, we measure threshold photoelectrons as photoelectrons to attain high detection efficiency. Tuning photon energy at the S 2s ionization threshold, the Auger electron spectra are recorded in coincidence with the threshold photoelectrons. We have observed the Auger lines associated with the formation of $OCS^{++}[(S\ 2p)^{-1}(V)^{-1}]$ states *via* the $L_1L_{2,3}V$ Coster-Kronig transitions, which are rather faster than usual Auger decay processes such as the *LVV* transitions. The corresponding Auger spectra measured in the ordinary way show broad structures due to the lifetime effect of the 2s hole states, however, at least five peaks can be observed in the coincidence spectra where the experimental resolution is restricted only by the instrumental resolution.