UVSOR Facility

IX-U Development of the UVSOR Light Source

IX-U-1 Successful Commissioning of New RF Cavity

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We have built a new main RF accelerating cavity for the UVSOR-II electron storage ring. The new cavity can generate RF voltage of 150 kV without replacing the high power RF transmitter whose maximum output power is 20 kW. The cavity was installed in a short straight section in the spring 2005. The design RF voltage of 150 kV was soon achieved in the high-power test operation without electron beam. After the high power test operation, the test operation with electron beam was started. By carefully observing the pressure rise in the cavity, we have decided to start the user operation with a moderately high RF accelerating RF voltage of 100 kV, which is twice higher than before. After the vacuum is completely recovered, the operation with the design voltage of 150 kV will be started. These high values of the accelerating voltage have made the low emittance operation possible without reducing the beam lifetime. Since May 2005, the UVSOR-II electron storage ring has been operated with a small emittance of 27 nm-rad for users.

IX-U-2 Ion Trapping Phenomena at UVSOR-II

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We have observed the dependence of the vertical betatron tune on the vacuum condition on the UVSOR-II electron storage ring. We changed the vacuum condition artificially by turning off the vacuum pumps. The betatron tune was measured by RF-KO method. During the experiment, the storage ring was operated in multi-bunch filling mode, in which successive twelve RF buckets were filled with electrons and other four buckets were kept empty. This result strongly suggested that the non-linear electric field produced by the ions trapped by the electron beam caused the betatron tune shift. We have observed betatron tune shifts were consistent with the theoretical predictions.

IX-V Researches by the Use of UVSOR

IX-V-1 Development of Velocity Imaging Spectrometer for Observing Negative Fragment Ions

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[*J. Electron Spectrosc. Relat. Phenom.* **148**, 5 (2005)]

A velocity imaging spectrometer has been developed to observe negative ions from molecular ion-pair dissociation. The imaging spectrometer furnishes with a pair of permanent magnets. The formed magnetic field effectively prevents the electrons' arrivals to the detector, without seriously affecting negative ions' flights. The performance of the imaging spectrometer is demonstrated in the observations of photoelectrons from O_2 and He, and O^- from O_2. Sample results on negative ion formation from O_2 and N_2O, prove that the present imaging method provides useful information on the assignments of superexcited states and the dynamical properties of ion-pair dissociation.

IX-V-2 Dynamics of Double Photoionization near the Ar 2p Threshold Investigated by Threshold Electron-Auger Electron Coincidence Spectroscopy

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[*J. Phys. B* **38**, L9 (2005)]

Threshold electron–Auger electron coincidence spectroscopy measurements were carried out near the Ar 2p thresholds. Such a method allows us, for the first time, to observe the threshold electron yields associated with the selected final states of the Ar^{2+} ion: $3p^4(^1D_2)$, $3p^4(^1S_0)$, $3p^4(^3P)$ resulting from the 2p hole Auger decay. All the spectra reveal strong PCI distortion. Comparison with calculations carried out in the framework of a quantum-mechanical PCI model allows us to clarify the mechanisms and the dynamics of threshold electron production. In the $3p^4(^1D_2)$ and $3p^4(^1S_0)$ channels, contribution to the threshold electron yield comes essentially from the PCI retardation of slow photoelectrons. In the $3p^4(^3P)$ final state channel, an additional process of valence multiplet decay of the $3p^4(^1D_2)6d$ state plays a role at and below the L_2, L_3 thresholds.

IX-V-3 Origin of Threshold Electrons Produced in Decay of the Xe $4d^{-1}np$ Resonance

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[*J. Electron Spectrosc. Relat. Phenom.* **142**, 319 (2005)]

Coincidence spectra of energetic electrons with threshold electrons were measured following photo-excitation of the Xe $4d_{3/2,5/2} \rightarrow np$ resonances, in order to investigate the origin of threshold electrons, and the mechanism leading to formation of the Xe^{2+} $5p^{-2}$ and $5s^{-1}5p^{-1}$ final states. A two-step decay process was observed in the production of Xe^{2+} $5p^{-2}(^1D)$ following decay of the 7p resonance, where the intermediate state is Xe^{+*} $5p^{-2}(^1S)8p$ that autoionizes emitting a pseudo-threshold electron. This process was confirmed in a time-of-flight analysis of the coincidence spectra of the energetic electrons with the threshold photoelectrons. It is suggested that a similar two-step process also contributes to the population of excited Xe^{2+} states and is the main origin for the production of threshold electrons in decay of the $4d^{-1}$ np resonances.

IX-V-4 Coincidence Auger Spectroscopy

PENENT, Francis[1,2]; LABLANQUIE, Pascal[3]; HALL, Richard[2]; PALAUDOUX, Jerome[1]; ITO, Kenji[4]; HIKOSAKA, Yasumasa; AOTO, Tomohiro[4]; ELAND, John H. D.[5]
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[*J. Electron Spectrosc. Relat. Phenom.* **144-147**, 7 (2005)]

Auger electron spectroscopy (AES) and photoelectron spectroscopy (PES) are (with X-ray emission spectroscopy, XES) powerful analytical tools for material science and gas phase studies. However, the interpretation of Auger spectra can be very difficult due to the number and complexity of the involved processes. A deeper analysis, that allows a better understanding of relaxation processes following inner shell ionization, is possible with coincidence Auger spectroscopy. This method gives a new insight into electron correlation and allows disentangling of complex Auger electron spectra. In this paper, we present some examples related to gas phase coincidence Auger electron spectroscopy using synchrotron radiation. The detection in coincidence of an Auger electron with a threshold photoelectron presents two main advantages which are good energy resolution and high coincidence count rates. This technique has also provided new results on double Auger decay processes. A further qualitative breakthrough has been made with the development of a new experimental set-up based on a magnetic bottle time-of-flight electron spectrometer. This opens up the field of multi-electron coincidence spectroscopy and allows a most detailed analysis with characterization of all possible decay pathways following inner shell ionization.

IX-V-5 Collision Dynamics of the Kr^{8+} + N_2 System Studied by a Multi-Coincidence Technique

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[*J. Phys. B* **38**, 1341 (2005)]

We have developed a multi-coincidence technique to study MCI-molecule collisions. Using this technique, complicated reaction processes and collision dynamics in Kr^{8+} + N_2 collisions have been successfully revealed in the energy region below 200 eV/u. The reaction processes in the single-, double-, triple- and quadruple-charge changing collisions are resolved and three low-energy collision phenomena, 'peak-shifting' of molecular ions, 'peak-splitting' and 'anisotropic fragmentation' of fragment ion pairs, are found in the time-of-flight spectra of target ions. By careful analysis of kinematics of all the products, it is concluded that the charge transfer in the Kr^{8+} + N_2 collisions is dominated by multi-electron capture processes followed by electron emission and the collision dynamics is characterized by the transverse momentum transfer from the ion to the molecule and the appearance of the 'anisotropic fragmentation.'

IX-V-6 Collision Dynamics of MCI-Molecule Systems Studied by Multi-Coincidence Technique

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([1]Tokyo Metropolitan Univ.)

[*Nucl. Instrum. Methods Phys. Res., Sect. B* **235**, 352 (2005)]

Collision dynamics and reaction processes in charge transfer collisions of Kr^{8+} + N_2 below 200 eV/u have been studied. We used a multi-coincidence technique which enables us to obtain kinematic information for both the fragment ions and the scattered projectile. The collision phenomena observed in the time-of-flight spectra of target ions are well clarified in consideration of the kinematics in colliding particles. We found an anisotropy in charge-unbalanced fragmentation channels at lower collision energy. The anisotropic behavior becomes significant not only with decreasing the collision energy but also with increasing the charge imbalance of the fragment ion-pair. The collision dynamics in the Kr^{8+} + N_2 system is characterized by the transverse recoil momentum and the anisotropic fragmentation.

IX-V-7 Optical Investigations of the Clathrate α-$Eu_8Ga_{16}Ge_{30}$

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[*Eur. Phys. J. B* **46**, 363–366 (2005)]

We performed measurements of the optical reflectivity in the energy range 0.007–30 eV on the clathrate-VIII type compound α-$Eu_8Ga_{16-x}Ge_{30-x}$ in order to investigate its electronic band structure. The very low charge carrier concentration as well as ferromagnetic ordering of the divalent Eu ions below 10.5 K characterize the spectra at photon energies below ~0.4 eV in accordance with the results of band structure calculations. Disorder induced bound states have been identified to affect the optical conductivity at energies between 10 and 100 meV.

IX-V-8 Influence of Cage Distortions on the Electronic Structure and Optical Properties of Ba_6Ge_{25}

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[*Phys. Rev. B* **72**, 045122 (7 pages) (2005)]

Measurements of the optical conductivity on Ba_6Ge_{25} reveal a shift of optical spectral weights towards higher energies, as temperature is lowered below the structural phase transition. This behavior may be understood from the structural modifications revealed from the new structure refinements of x-ray diffraction data from high quality single crystals. Apart from Ba atoms, some Ge cage atoms are also shifted into distant split sites below the phase transition. In this way one covalent bond is broken between the corresponding Ge atoms and they become threefold bonded. Electronic band structure calculations for the low symmetry ordered model show that the bond breaking causes a shifting of three bands from the conduction to the valence region. This leads to a shifting of optical spectral weights towards higher energies, which is in agreement with the experimental data.

IX-V-9 Indirect and Direct Energy Gaps in Kondo Semiconductor YbB_{12}

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[*J. Phys. Soc. Jpn.* **74**, 1954–1957 (2005)]

The optical conductivity [$\sigma(\omega)$] of the Kondo semiconductor YbB_{12} has been measured over wide ranges of temperature (T = 8–690 K) and photon energy ($h\nu \geq$ 1.3 meV). The $\sigma(\omega)$ data reveal the entire crossover of YbB_{12} from a metallic electronic structure at high T's to a semiconducting one at low T's. Associated with the gap development in $\sigma(\omega)$, a clear onset is newly found at $h\nu$ = 15 meV for $T \leq$ 20 K. The onset energy is identified as the gap magnitude of YbB_{12} appearing in $\sigma(\omega)$. This gap in $\sigma(\omega)$ is interpreted as the indirect gap, which has been predicted by the renormalized-band model of the Kondo semiconductor. On the other hand, the strong mid-infrared (mIR) peak observed in $\sigma(\omega)$ is interpreted as arising from the direct gap. The absorption coefficient around the onset and the mIR peak indeed show the characteristic energy dependences expected for indirect and direct optical transitions in conventional semiconductors.

IX-V-10 Kondo Ground States and Non-Fermi-Liquid Behavior in $CeNi_{1-x}Co_xGe_2$

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[*Phys. Rev. B* **71**, 214433 (9 pages) (2005)]

We report measurements of the magnetic susceptibility, specific heat, and electrical resistivity of the heavy fermion alloy series $CeNi_{1-x}Co_xGe_2$. With increasing x, hybridization between the localized 4f and conduction band electrons is enhanced. The magnetic order observed at x = 0 is completely suppressed at x = 0.3 and non-Fermi-liquid behavior appears at the critical concentration, which is analyzed in terms of two-dimensional antiferromagnetic quantum fluctuations. Specific heat and magnetic susceptibility data are quantitatively explained by the Coqblin-Schrieffer model with degenerate impurity spin j = 1/2, 3/2, and 5/2 for Co concentration range of $x \leq 0.6$, $0.7 \leq x \leq 0.8$, and $x \geq 0.9$, respectively.

IX-V-11 Infrared Spectroscopy under Multiextreme Conditions: Direct Observation of Pseudogap Formation and Collapse in CeSb

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[*Phys. Rev. B* **71**, 220401(R) (4 pages) (2005)]

Infrared reflectivity measurements of CeSb under multiextreme conditions (low temperatures, high pressures, and high magnetic fields) were performed. A pseudogap structure, which originates from the magnetic band folding effect, responsible for the large enhancement in the electrical resistivity in the single-layered antiferromagnetic structure (AF-1 phase) was found at a pressure of 4 GPa and at temperatures of 35–50 K. The optical spectrum of the pseudogap changes to that of a metallic structure with increasing magnetic field strength and increasing temperature. This change is the result of the magnetic phase transition from the AF-1 phase to other phases as a function of the

magnetic field strength and temperature. This result is an important optical observation of the formation and collapse of a pseudogap under multiextreme conditions.

IX-V-12 Infrared Study on CeSb under High Pressures

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[*Physica B* **359-361**, 190–192 (2005)]

The optical reflectivity spectra ($R(\omega)$) of CeSb have been measured at high pressures to investigate the origin of the physical properties appearing under pressures. At 300 K, the pressure dependence of $R(\omega)$ revealed that the carrier density proportionally increases with increasing pressure up to 2.5 GPa. At lower temperature, the $R(\omega)$ spectrum drastically changes with both temperature and pressure due to the complex magnetic phase diagram. Especially, at 2.5 GPa and 30 K, the $R(\omega)$ intensity below 0.2 eV decreases, on the contrary that at around 0.3 eV increases. This result suggests that the density of states near the Fermi level decreases and shifts to the high-energy side.

IX-V-13 Electronic Structure of Bulk Metallic Glass $Zr_{55}Al_{10}Cu_{30}Ni_5$

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[*J. Electron Spectrosc. Relat. Phenom.* **144-147**, 585–587 (2005)]

The electronic structure of a bulk metallic glass $Zr_{55}Al_{10}Cu_{30}Ni_5$ has been studied by means of photoelectron spectroscopy in order to understand the origins of its large glass formation ability and unique mechanical properties from the microscopic point of view. The valence-band photoelectron spectra show three bands ascribed to the Zr 4d, Ni 3d, and Cu 3d states. A remarkable feature of these bands is the highly symmetric spectral shape with the high-binding energy and narrow width in comparison with the d bands of the crystalline transition metals. This is attributed to the lack of the crystalline periodicity in the metallic glass as well as the reduction in the neighbouring atoms to hybridize with those transition metals. A high-resolution valence-band spectrum also reveals the intensity reduction near the Fermi level, which implies that the pseudo-gap in the electronic structure may be one of the important factors for the glass formation.

IX-V-14 Carrier-Induced Infrared Magnetic Circular Dichroism in the Magnetoresistive Pyrochlore $Tl_2Mn_2O_7$

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[*J. Phys. Soc. Jpn.* **74**, 970–974 (2005)]

Infrared magnetic circular dichloism (MCD), or equivalently magneto-optical Kerr effect, has been measured on the $Tl_2Mn_2O_7$ pyrochlore, which is well known for exhibiting a large magnetoresistance around the Curie temperature $T_C \sim 120$ K. A circularly polarized, infrared synchrotron radiation is used as the light source. A pronounced MCD signal is observed exactly at the plasma edge of the reflectivity near and below T_C. However, contrary to the conventional behavior of MCD for ferromagnets, the observed MCD of $Tl_2Mn_2O_7$ grows with the applied magnetic field, and not scaled with the internal magnetization. It is shown that these results can be basically understood in terms of a classical magnetoplasma resonance. The absence of a magnetization-scaled MCD indicates a weak spin-orbit coupling of the carriers in $Tl_2Mn_2O_7$. We discuss the present results in terms of the microscopic electronic structures of $Tl_2Mn_2O_7$.

IX-V-15 Magnetic Ordering in Frustrated $Ce_5Ni_2Si_3$

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[*Phys. Rev. B* **70**, 224409 (5 pages) (2004)]

The transport, magnetic, and thermal properties are studied on an antiferromagnetic compound $Ce_5Ni_2Si_3$ with $T_N = 7.3$ K. We find signatures of spin fluctuation in this geometrically frustrated magnet. The Curie-Weiss fit gives a large value of the paramagnetic Curie temperature, yielding a frustration parameter $f = 8.4$. The electronic specific heat coefficient $\gamma = 300$ mJ/Ce mol K^2 is strongly enhanced, leading to residual entropy at low temperatures. The spin fluctuation is suppressed as the magnetic field exceeds the metamagnetic transition field $H_m = 1$ T, where the magnetoresistance decreases steeply. The steady increase of magnetic susceptibility below T_N is likely to be associated with the presence of paramagnetic Ce ions. For $La_5Ni_2Si_3$, a superconducting transition is observed at $T_C = 1.8$ K.

IX-V-16 Features of Fluorescence Spectra of Polyethylene Terephthalate Films

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[*Jpn. J. Appl. Phys.* **43**, 8107–8114 (2004)]

Out of two species of fluorescence of polyethylene terephthalate (PET), intrinsic fluorescence (I), which was caused by short-wavelength (< 320 nm) excitation, was dominant for very thin films (less than a few microns), while, trap fluorescence (II), excited at longer wavelengths (>320 nm), was much more intense for thick films. This fact was confirmed, and explained by an elementary formula. Effects of polymerization catalysts onto the fluorescence spectra were found to be indirect; namely, peak positions of the fluorescence were not affected by catalyst systems, while fluorescence intensity was sensitive not only to catalyst systems but also to minute differences in local surroundings. Effects of catalyst systems on the weak absorption bands at 338 nm and 354 nm were examined. Integrated excitation spectra were resolved; therein, a hidden $n \rightarrow \pi^*$ state was found. Most likely, this is related with the weak absorptions at 338 nm and 354 nm, which are the major origins of fluorescence (II).

IX-V-17 Anomalous Magnetic Properties and Non-Fermi-Liquid Behavior in Single Crystals of the Kondo Lattice $CeNiGe_{2-x}Si_x$

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[*J. Phys.: Condens. Matter* **16**, 8323–8334 (2004)]

We report on the magnetic susceptibility, specific heat and electrical resistivity of the heavy fermion compounds $CeNiGe_{2-x}Si_x$ ($0 \le x \le 1$). Compounds with $x < 1$ show antiferromagnetic order, which with increasing x shifts toward lower temperature owing to increased exchange coupling between the localized 4f magnetic moments and conduction electrons. Eventually, the magnetic order almost becomes absent, for $x = 1$. An anomaly observed in the specific heat is well interpreted by the Kondo model for a degenerate impurity spin $J = 1/2$ in the Coqblin–Schrieffer limit. A coherence peak indicative of the formation of a Kondo lattice is found in the electrical resistivity, whose features are consistent with the results for the specific heat. Interestingly, there is a significant deviation from Fermi-liquid behaviour at the critical concentration $x = 1$. This deviation is attributed to a quantum phase transition in a model with two-dimensional antiferromagnetic fluctuations.

IX-V-18 Sub-Natural Linewidth Auger Electron Spectroscopy of the 2s Hole Decay in HCl

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Auger-photoelectron coincidence spectroscopy, in which Auger electrons are measured in coincidence with the corresponding photoelectrons, can be a powerful tool to elucidate the decay dynamics of the core-hole states followed by the productions of doubly charged atomic and molecular ions. In our coincidence method, we measure threshold photoelectrons as photoelectrons to attain high detection efficiency. We have applied the coincidence method to the 2s hole decay in HCl. We tuned photon energy at the Cl 2s ionization threshold of HCl, and recorded the Auger electron spectrum in coincidence with the threshold photoelectrons. We have observed the Auger lines associated with the formations of $HCl^{++}[(Cl\ 2p)^{-1}(V)^{-1}]$ states *via* the $L_1L_{2,3}V$ Coster-Kronig transitions, which are much faster than other Auger decay processes such as the LVV transitions. Ordinary Auger spectrum measured without any coincidences shows only broad structures due to the wide natural linewidth of the 2s hole states (1.8 eV FWHM). In contrast, several peaks appear on the coincidence spectrum we obtained, thanks to the sub-natural linewidth regime which is achieved by the coincidence observation using the high resolution spectrometers.