

High-resolution angle-resolved photoelectron spectroscopy of CO₂ in the C 1s and O 1s ionization regions

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Photoabsorption spectra of small molecules often exhibit resonant features above the inner-shell thresholds. These shape resonances are conventionally described as one-electron phenomena associated either with temporary trapping of the photoelectron by the molecular potential or with the promotion of a core electron to an unoccupied molecular orbital. Recent core-level photoemission study has revealed that multielectron excitations play important roles in the shape resonance regions, raising questions about the validity of one-electron descriptions. Such multielectron transitions have so far been interpreted as results of a shake-up mechanism. Recently, we have found that inelastic scattering of the photoelectron with the remaining molecular ion core also play a significant role [1].

In the present work, we have investigated the effects of the photoelectron impact onto the vibrational and electronic excitations of the remaining ion core, applying the high-resolution angle-resolved photoelectron spectroscopy to CO₂ molecule. The experiment was carried out on the high-

resolution monochromator installed in the beamline 27SU using a high-resolution electron energy analyzer SES2002.

The 4σ_u resonance lies ~14 eV above the C/O 1s thresholds whereas the 5σ_g resonance lies ~ 1.3 eV above the O 1s threshold: the transition C 1s σ_g → 5σ_g is dipole forbidden. We have recorded the vibrationally resolved C 1s photoelectron main band, as well as the satellites, as a function of photon energy across the 4σ_u resonance. The vibrational branching ratios vary dramatically across the shape resonance and the asymmetry parameters are quite different for different vibrational components. Also we have recorded the vibrationally resolved O 1s photoelectron main band as a function of the photon energy across the 5σ_g shape resonance. The vibrational branching ratios vary as a function of photon energy, whereas the asymmetry parameters are similar for all vibrational components. Further detailed analyses are in progress.

Photoelectron diffraction of free clusters: Angle-resolved photoelectron spectroscopy of argon dimers fixed in space

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Core-level photoelectron waves emitted from a specific atomic site in a cluster are diffracted by the neighbor atoms. The diffracted wave interferes with the direct wave (reference wave). As a result, a photoelectron current plotted as a function of angles within the body frame of the cluster is expected to exhibit the interference pattern. We may call it *photoelectron diffraction* or *holography* of a cluster. Photoelectron diffraction has been widely used to investigate the surface structure. We report the first measurement of the photoelectron diffraction of the cluster, using the Ar dimer as a simplest example.

The experiment was carried out on BL27SU, using a multiple coincidence momentum imaging technique. This technique allows us to register three-dimensional momentum for each of all the electrons and ions detected in coincidence. Examining the momenta of the two Ar ions recorded in coincidence, we select the Ar dimer from other Ar clusters with the help of the momentum conservation law. Then we extract the photoelectron angular

distribution relative to the axis of the Ar dimer recorded in coincidence. Figure 1 shows an example of the polar plots for the angular distribution of the Ar 2p photoelectrons with kinetic energy 15 eV, relative to the dimer axis, after integrated over the direction of the light polarization vector. An estimate of the angular distribution using a known Ar-Ar distance (0.374 nm) reproduces well the observed interference pattern, illustrating the potential applicability of the photoelectron diffraction to the structure analysis of free clusters.

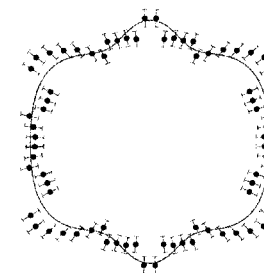


Fig.1 Angular distribution of the Ar 2p photoelectron emitted from the Ar dimer fixed in space. The solid line is a simple estimate of the photoelectron diffraction pattern with a known Ar-Ar distance.