Inner-valence ionization of N_2 studied by molecular-frame EELS experiments

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Synopsis We report molecular-frame electron scattering cross sections of N_2, obtained using an electron-ion coincidence technique. The vector correlation between the scattered electron and the fragment ion has been measured at incident electron energy of 1.4 keV for inner-valence ionization of N_2. The angular distributions of the electron scattering cross sections thus obtained exhibit clear momentum transfer dependence, indicating the significant change of the ionization dynamics due to contributions from electric multipole transitions.

In the past five decades, angle resolved electron energy loss spectroscopy (EELS) has proven to be a powerful means for investigating electron excitation processes of atoms and molecules. The momentum transfer dependence of the electron scattering cross section provides deep insights into the nature of electron excitation processes of interest [1]. EELS studies on molecules have, however, long been restricted to investigating targets with random spatial orientation; the spherical averaging over the molecular orientation results in enormous loss of information on the electron-molecule collision dynamics. To remove ambiguities in the analysis of the spherically averaged EELS cross sections, we have recently developed a method to perform EELS experiments in a molecular frame, which involves a coincidence detection of the scattered electron and fragment ion [2]. In this work we have applied the method to the study of inner-valence ionization of N_2. In the inner-valence region, a number of two-hole one-particle ionic states appear. Since the major mechanisms responsible for transitions to such ionic states are configuration interactions in the target molecule, the inner-valence ionization offers an ideal opportunity for investigating ionization dynamics of molecules beyond the independent-particle model.

An electron-ion coincidence apparatus developed in our laboratory consists of an electron gun, a molecular beam source, a hemispherical electron analyzer, and an ion momentum imaging spectrometer equipped with a position sensitive detector. A pulsed electron beam is crossed with gaseous targets expanded from a nozzle and electrons scattered at a particular angle of θ are energy analyzed using the hemispherical electron spectrometer. Once a scattered electron is detected, a homogeneous electric field is applied to the scattering region to push fragment ions into the ion spectrometer. The recoil-momentum of the ion is determined from its time of flight and arrival position at the position sensitive detector.

By using the apparatus we have performed molecular-frame EELS experiments on N_2 at incident electron energy of 1.4 keV. Fig. 1 shows the EELS cross sections thus obtained for the ionization to the F $^2\Sigma_g^+$ two-hole one-particle state at energy loss of 38 - 40 eV. In the figure the EELS cross sections are plotted as a function of the angle ϕ_K of momentum transfer vector $\boldsymbol{K}$ from the molecular axis. It exhibits clear ϕ_K dependence and the angular distribution considerably varies with the increase in K. The result indicates that contributions from electric multipole transitions lead to the significant change of the ionization dynamics.

In the presentation we will show the results for transitions to other ionic states and discuss how information on ionization mechanisms is manifested in the angular distribution and its momentum transfer dependence.

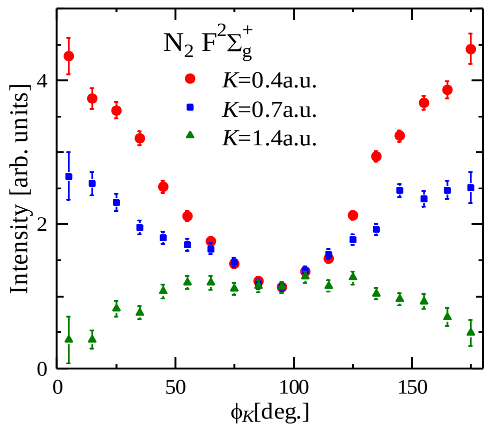

Figure 1. Molecular frame EELS cross section of N_2 for the transition to the F $^2\Sigma_g^+$ state.

References

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