Inelastic x-ray scattering technique and its application on determining the electronic structures of atoms and molecules

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Synopsis Non-resonant inelastic x-ray scattering (NRIXS) is a powerful tool to reveal the electronic structures of matter while it has a very low cross section. Recently we have extended the NRIXS to atomic and molecular physics with a low-density target. The electronic structures of the ground/excited states and the photoabsorption cross sections of some atoms and molecules have been determined by NRIXS and the newly-developed dipole（γ,γ）method.

Electronic structures of the ground and excited states of atoms or molecules are of fundamental importance to atomic and molecular physics, and are investigated by the high energy electron scattering method traditionally. However, the electron scattering method has its intrinsic merits and demerits. One of its merits is the large scattering cross sections, and one of its demerits is the strong interaction between the incident electron and target which leads to the invalidity of the first Born approximate (FBA), and that will complicate the explanation of the experimental observations. Furthermore, the differential cross section (DCS) of high-energy electron scattering rapidly diminishes with a rate of q^{-4} as the momentum transfer increases, so it is difficult to measure the dynamic parameters at large momentum transfer. However, NRIXS method has the advantages that the FBA is almost always satisfied, which provides a powerful tool to study the dynamic parameters and the electronic structures of the ground and excited states of atoms and molecules.

The disadvantage of IXS is its very low cross sections, i.e., about $10^{-29}m^2$, and it is the reason that the x-ray scattering technique is extensively used in condensed matter physics rather than in atomic and molecular physics. Recently, with the dramatic progress of the third generation synchrotron radiation and crystal analyzer, it provides the possibility to measure the dynamic parameters and electronic structures of atoms and molecules by using the high-resolution IXS.

Utilizing the high flux of the third generation synchrotron radiation and high density target sealed in a gas cell at about 1 MPa, we recently realized absolute dynamic parameter measurements of atoms and molecules by the IXS [1,2]. The electronic structures of the ground and excited states of some atoms and molecules [3-12] have been determined by the IXS at incident photon energies of about 10 keV and energy resolution of about 70 meV.

Recently, the generalized oscillator strenghts (GOSs) for the valence-shell excitations of acetylene have been measured, and the primary result for R30 is shown in Fig.1.

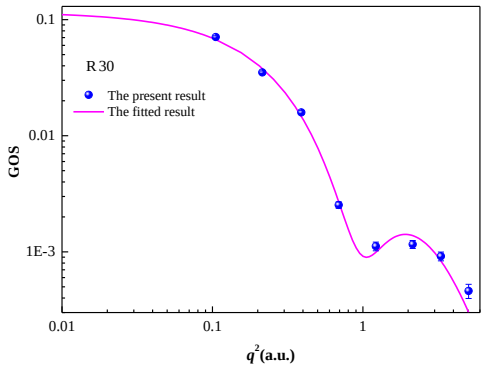

Fig.1 The GOS of R30 state of acetylene measured by the IXS

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