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Studies of threshold behaviors of the photoionization of molecular hydrogen and its isotopmer by the photoelectron spectroscopy

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1 Introduction

The photoionization of molecular hydrogen and its isotopmers is one of the simplest model systems for the study of photoionization dynamics of molecules. Photoionization spectra of molecular hydrogen near the ionization thresholds are known to show comprehensive structures due to dense autoionizing resonances lying nearby [1]. Threshold photoelectron spectroscopy combined with tunable high-resolution VUV photon-sources has been the powerful tool for discovering threshold behavior of photoionization of various molecules.

Previously, present group has measured threshold photoelectron spectra of H_2, D_2 and HD in the photon energy range of 15.4 – 18.2 eV. From the threshold photoelectron spectra, vibrational band dependence of the relative direct photoionization cross sections of H_2, D_2 and HD were obtained, with the aid of photoion yield spectra measured simultaneously. The vibrational band dependence of the relative direct threshold-photoionization cross sections of H_2 showed a weak minimum at v'=6. The relative direct threshold-photoionization cross sections for D_2 and HD also showed weak minimum at v'=8 and v'=7, respectively. The photon energies of observed minimum for all isotopmers were found to coincide at 16.8 eV.

In the present study, vibrational band dependences of the direct-photoionization cross sections of molecular hydrogen and its isotopmer were studied at very close to the ionization threshold with ordinary photoelectron spectroscopy.

2 Experiment

The experiments were performed at the VUV beamline 20A of the Photon Factory, KEK. The photoelectron spectra were measured with a high-resolution photoelectron spectrometer Gammadata Scienta SES-4000R equipped with a gas cell DC-50. The spectrometer lens axis lies in the horizontal direction, perpendicular to the photon beam direction. The recorded electron spectra correspond to the electron emission parallel to the electric vector of the photon beam.

In order to measure photoelectrons with energies very close to 0 eV, operation voltages of the electron lenses were re-adjusted in the present study. The lowest kinetic energy of the photoelectron measurable in the present experiment was 30 meV. In addition, in order to reduce the scattering of the synchrotron radiation inside the gas cell, an aperture with a hole of 2 mm in diameter was attached to the gas cell. Photoelectron spectra were obtained at photon energies between 15.4 – 18.05 eV. The relative partial photoionization cross sections of each vibrational bands were obtained by normalization to the photoelectron spectra of Ar obtained under the same condition.

3 Results and Discussion

Figure 1 shows the contour plot of the photoelectron spectra of H_2 measured with photon energies of 0.04 eV step at 15.4 – 17.1 eV and 0.2 eV step at 17.1 – 18.05 eV. The spectra were calibrated with the apparatus function and hence correspond to the relative partial photoionization cross sections of each vibrational band.

Each vibrational bands show enhancement of the autoionizing resonances at small kinetic energy region. On the other hand, the weak minimum of the vibrational band dependence of the photoionization cross sections of v'=6 band has not been observed at 16.8 eV.

Since the cross-section minimum for v'=6 peak has not been clearly observed in the photoelectron spectra, the cross-section minimum observed in the threshold photoelectron spectra seems to be a characteristic feature only at the region from the ionization threshold to 30 meV above the threshold.

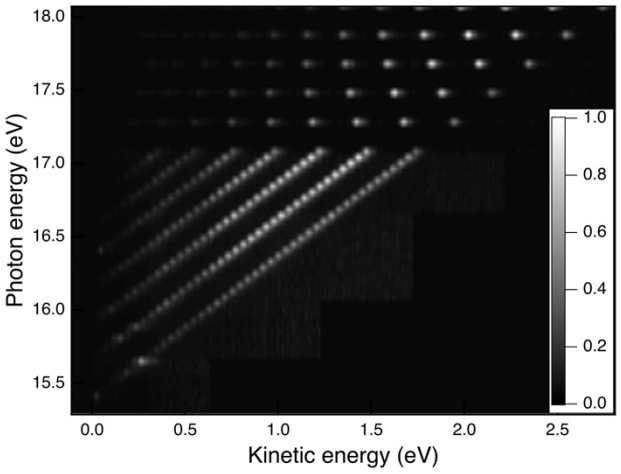

Fig. 1: The contour plot of the photoelectron spectra of H_2.

References

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