Metastable hydrogen in the 2s state as a probe for dissociative doubly excited states of molecules

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Synopsis The cross sections for the production of the H(2*s*) atom in photoexcitation of CH_4 and NH_3 have been measured as a function of the incident photon energy. Dissociative doubly excited states of CH_4 and NH_3 have been observed clearly in the cross section curves. A method to measure the velocity of the metastable fragments in photodissociation of molecules was newly developed.

The dynamics and spectroscopy of doubly excited states of molecules are subjects of great interest in atomic and molecular physics since the wave functions are not simply described as a Born-Oppenheimer product due to the coupling with ionization continua [1]. Such doubly excited states embedded in the electronic continua are well observed in cross sections free from ionization such as dissociation cross sections [2]. In the present study, the cross sections for the production of metastable hydrogen in the 2*s* state in photoexcitation of CH_4 and NH_3 were measured as a function of the incident photon energy.

The measurements were carried out at BL-20A of the Photon Factory, KEK. The experimental details were described in Odagiri *et al.* [3].

Figure 1 shows the cross sections for the production of the H(2*s*) atom from photoexcited CH_4 (a) and NH_3 (b) as a function of the incident photon energy. By a fitting based on a semi-classical analysis, superexcited states of CH_4 and NH_3 were found in the cross sections as shown by the dotted curves in the figure. Among them, the three peaks at 29.7, 35.0 and 39.3eV in figure 1 (a) and the peak at 31.6eV in figure 1 (b) were attributed to the doubly excited states. The doubly excited states of CH_4 seem to be the same that were observed in the cross sections to form H(2*p*) atoms in the photoexcitation of CH_4 [4] .

For further investigations on the dynamics of the dissociative doubly excited states of molecules, we developed a new method based on a time-of-flight technique and the pulsed synchrotron light source for measuring the velocity of the metastable fragments in the photodissociation of molecules.

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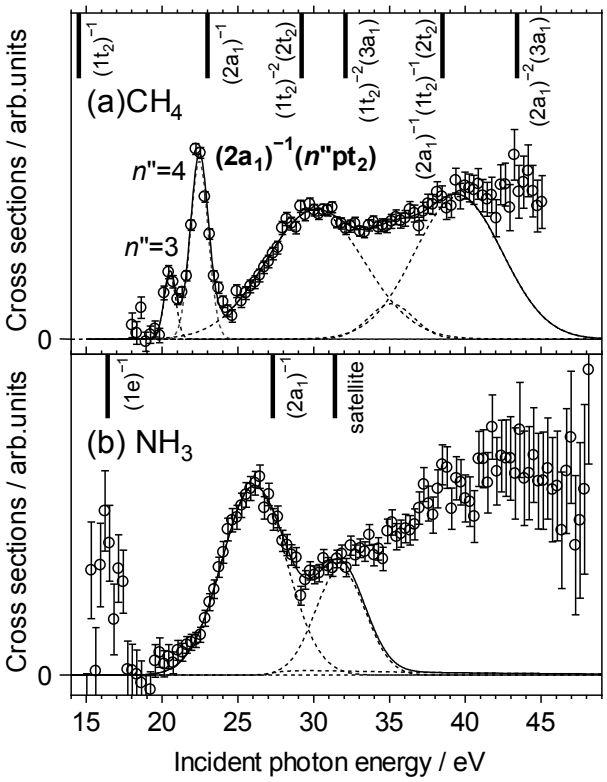

Figure 1. Cross sections for the production of the metastable hydrogen atom in the 2s state for (a) CH_4 and (b) NH_3 as a function of the incident photon energy. The vertical ionization potentials of CH_4 [5] and NH_3 [6] are displayed by thick vertical bars. The curves show the results of the fits by the semi-classical analysis.

References

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