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Time-of-flight measurement of metastable atomic hydrogen produced in photoexcitation of H_2 for investigating the formation and decay of the doubly excited states

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1 Introduction

The wavefunctions of doubly excited states of molecules are not simply described by the Born-Oppenheimer product due to the configuration mixing with the ionization continuum. Thus the formation and decay of them is an interesting and important subject in fundamental sciences. It has been shown that the doubly excited states are well observed in cross sections for the formation of neutral fragments in photoexcitation of molecules. In the present study, time-of-flight (TOF) of the neutral fragments produced in photodissociation of H_2 was measured for studying the dynamics of the doubly excited states in more detail. Measureing the TOF of the neutral fragments would be of great service in disentangling the cross section curve in which close lying doubly excited states contribute.

2 Experiments

The measurements were carried out by using the pulsed synchrotron radiation (SR) obtained from the single bunch operation of the storage ring. Figure 1(a) shows the scheme of the experiments. The metastable atomic hydrogen in the 2*s* state, H(2*s*), fling through the flight tube with the length of approximately 100 mm were detected by a microchannel plate (MCP). It can detect not only the H(2*s*) atoms but also other particles such as electrons, ions and photons produced in photoexcitation of H_2 as the backgrounds. The electrons and ions were eliminated by applying a magnetic field inside the flight tube. The signals due to the photons can be distinguished from the H(2*s*) signals in the time domain (see figure 2). The flight times of the H(2*s*) atoms are expected to be several micro seconds which are much longer than the recurrence time of the pulsed SR, 624 ns. Hence, to avoid overlapping of the TOF spectra a pulsed quenching electric field was applied at the entrance of the flight tube in order to quench out the H(2*s*) atoms produced by the other pulsed SR (see the timing chart of figure 1(b)). The 2*s* state of atomic hydrogen mixes with the 2*p* state by the stark effect due to the electric field and the atom decays to the ground state by emitting a Lyman-α photons.

3 Results and Discussion

The TOF spectra of the H(2*s*) atoms measured at incident photon energies of 33.5 and 34.0 eV are shown in figure 2. A spike structure due to the photons produced in photoexcitation of H_2 was observed in every 624 ns in the TOF spectra. On the other hand, the peaks around approximately 3.5 μs in figures 2(a) and 2(b) are attributed to the H(2s) atoms, which are the first success of measuring TOF of the neutral atoms by means of the SR.

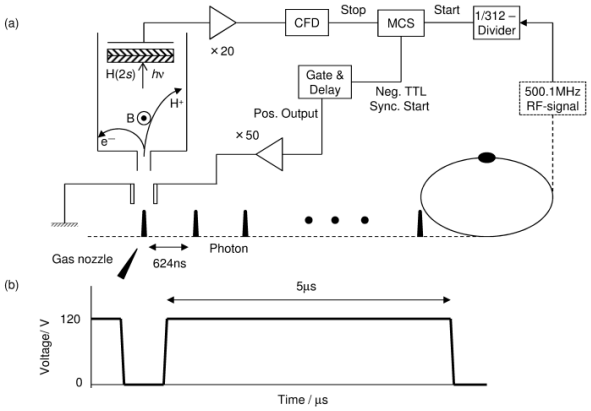

Figure 1. The scheme of the time-of-flight measurement (a) and the timing chart of the pulsed quenching electric field (b).

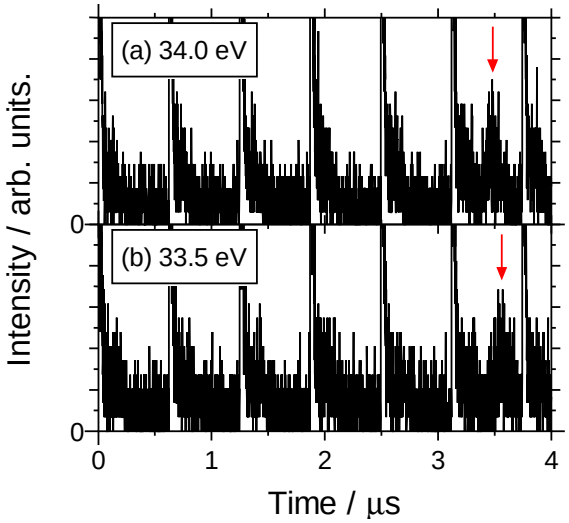

Figure 2. The time-of-flight spectra of the H(2*s*) atoms produced in photodissociation of H_2 at incident photon energies of 34.0 eV (a) and 33.5 eV (b).

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