The observation of the pair of Lyman-α and Lyman-β photons produced in the photodissociation of H_2

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Synopsis We have measured the coincidence time spectra for the pair of the Lyman-α and Lyman-β photons produced in the photodissociation of H_2 in the range of the incident photon energy 32.5 - 42 eV. The result shows that the pair of H(2p) and H(3p) fragments is produced in the photodossociation of H_2 molecules.

Coincidence detection of the pair of fluorescence photons emitted by the pair of excited photofragments, the $(\gamma,2\gamma)$ method, is a powerful technique for investigating the dynamics of the doubly excited molecules produced by the photon interaction. The $(\gamma,2\gamma)$ study on H_2 molecules enabled us to study the dynamics of the doubly excited $Q_2\ ^1\Pi_u(1)$ state[1, 2] and the entanglement of the pair of H($2p$) atoms[3], where the pair of the Lyman-α photons ($2p \to 1s$, 121.6nm wavelength[4]) was detected in coincidence. In the present study, the $(\gamma,2\gamma)$ method has been extended to the coincidence detection of the pair of the Lyman-α and Lyman-β ($3p \to 1s$, 102.6nm wavelength[4]) photons produced in the photoexcitation of H_2 molecules. Our Lyman-α detector is comprised of a 1 mm-thickness MgF_2 window($\sim$60% transmittance for the Lyman-α photon) and microchannel plate coated with CsI, which provides a filter range of approximately 115 - 200 nm[2]. For the Lyman-β detector, the MgF_2 window is replaced with the 100 nm-thickness Indium Oxide(InO) foil[5] ($\sim$8% transmittance for the Lyman-β photon).

The experiments were performed at BL20A of the Photon Factory, KEK, Japan. Linearly polarized light was introduced into a gas cell filled with H_2 gas. The two-photon coincidence time spectra were measured in the range of the incident photon energy 32.5 - 42 eV, and they were summed up to get better statistics. The result is shown in Fig.1, where the accidental coincidence counts were subtracted. The horizontal axis of Fig. 1 expresses the detection time of the Lyman-α photon(T_α) in reference to the detection time of the Lyman-β photon(T_β).

Two decay components are seen in addition to the sharp peak, which originates from the cosmic muons [3]. The slow decay component, which ranges from late time to early time, has the time constant close to the lifetime of $3p$ atom, 5.4 ns[6]. It is difficult to know the time constant of the fast decay component, which ranges from early time to late time, since the sharp peak prevent it from being separated. However, the time constant of the fast decay component seems consistent with the lifetime of the $2p$ atom, 1.6 ns [6]. In conclusion, the coincidence time spectra in Fig.1 shows that the pair of H($2p$) and H($3p$) atoms is produced in the photodissociation of H_2 molecules.

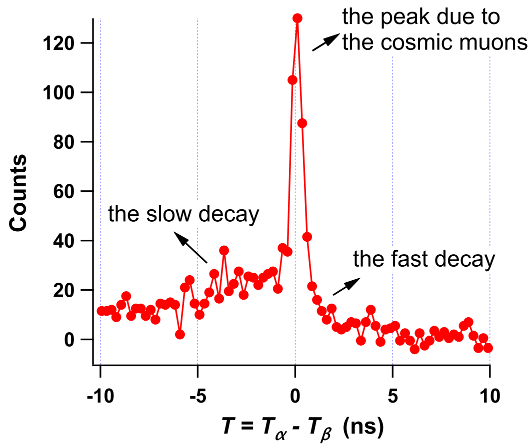

Figure 1. The coincidence time spectrum between the Lyman-α and Lyman-β photons produced in the photodissociation of H_2.

References

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