20A/2001G198

(γ, 2γ) studies on doubly excited states of molecular hydrogen

Takeshi ODAGIRI*, Makoto MURATA, Masahiro KATO, Kensaku KODAMA, Noriyuki KOUCHI
Department of Chemistry, Tokyo Institute of Technology, Meguro-ku, Tokyo 152-8551, Japan

Introduction

Doubly excited states of molecules are well probed by fluorescences from photodissociation fragments produced from them since contribution of direct ionization is eliminated from fluorescence cross-sections and then the spectral features due to the doubly excited states are noticeable [1]. In higher energy region, however, dissociative ionization with excitation comes to contribute in the fluorescence cross-sections, making it difficult to investigate spectroscopy and dynamics of the doubly or multiply excited states of molecules. In the present study, we focus on the following process (neutral dissociation with simultaneous excitation)

$H_2 + h\nu \text{ -- > } H_2^{**}$

$\text{ -- > } H(2p) + H(2p)$ (1)

$\text{ -- > } H(1s) + H(1s) + \text{Ly-}\alpha + \text{Ly-}\alpha.$

Coincidence detection of two Lyman-α photons enables us to observe only the process (1) and complete elimination of ionization process is achieved. A cross section curve attributed entirely to the doubly excited states of H_2 has been obtained for the first time.

Experimental

Experiments were carried out at BL20A equipped with a 3-m normal incidence monochromator. Lyman-α photons were detected by two photon detectors placed opposite to each other and aligning on the line parallel with the electric vector of the linearly polarized incident SR light. Each photon detector is composed of a microchannel plate and an MgF_2 window, providing filter range of 115-150 nm. Pulses from two detectors are fed into a standard delayed-coincidence circuit. Pressure in the gas cell was maintained at approximately 1.5 mtorr so that the coincidence count rate is approximately linear as a function of pressure in this range. Resolution of the wavelength of the incident light is estimated to be 0.28 nm: energy resolution of 280 meV at 35 eV incident photon energy.

Results

An example of coincidence time spectra is shown in figure 1. True coincidence rates are normalized for target number density, incident photon flux and geometrical factor to obtain the relative cross sections for the process (1), which are plotted in figure 2 as a function of incident photon energy. The cross sections increase around 30 eV, which is much higher than the dissociation limit of H(2p)+H(2p), i.e., 24.9 eV [2].

In figure 2, theoretical cross section due to the Q_2 $^1\Pi_u(1)$ state of H_2 calculated by the reflection approximation and semi-classical treatment is also shown. The experimental cross-section curve in figure 2 seems to agree well with the theoretical one in terms of shape, which may indicate the validity of such a simple approach for the formation and decay of the doubly excited Q_2 $^1\Pi_u(1)$ state.

References

[1] M. Kato et al., J. Phys. B 35, 4383 (2002).
[2] T. E. Sharp, At. Data 2, 119 (1971)

* joe@chem.titech.ac.jp

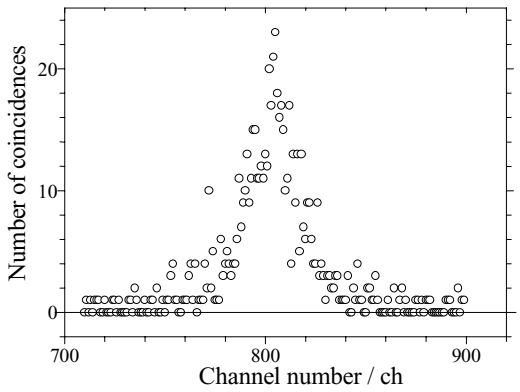

Figure 1. A coincidence time spectrum measured at the incident photon energy of 34.3 eV (approximately 0.4 ns / channel).

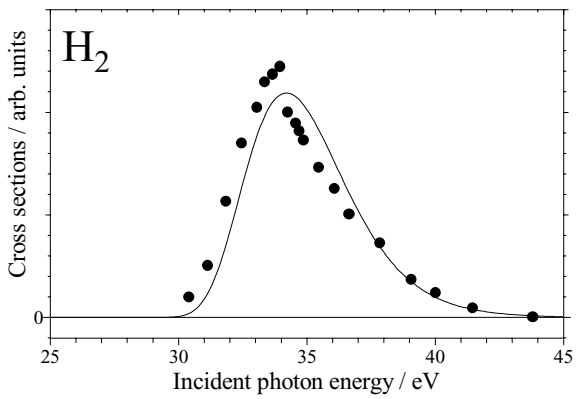

Figure 2. Relative cross sections for the neutral dissociation with simultaneous excitation, process (1) (closed circles). Theoretical cross section due to Q_2 $^1\Pi_u(1)$ of H_2 is also displayed by solid curve (see text).