BL-20A/2013G078

A new setup to investigate temperature dependence on VUV-photoabsorption cross sections of vibrationally-excited molecules

Masamitsu Hoshino[1,*], Midori Matsui[1], Yu Mochizuki[1], Koichiro Shibazaki[1], Yohei Ishijima[1], Atsushi Suga[1], Takeshi Odagiri[1], Keisuke Shigemura[2], Atsushi Kondo[2], Masashi Kitajima[2], Noboru Watanabe[3], Junichi Adachi[4], Paulo Limão-Vieira[5], and Hiroshi Tanaka[1]

[1] Department of Material and Life Sciences, Sophia University, 102-8554 Tokyo, Japan.
[2] Department of Chemistry, Tokyo Inst. of Tech., Meguro-ku, Tokyo 152-8551, Japan.
[3] Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Sendai 980-8577, Japan.
[4] Photon Factory, Institute of Materials Structure Science, Tsukuba 305-0801, Japan.
[5] Laboratório de Colisões Atómicas e Moleculares, CEFITEC, Departamento de Física, FCT-Universidade Nova de Lisboa, Campus de Caparica, P-2829-516 Caparica, Portugal.

We have developed a new setup to measure temperature dependence on vacuum ultraviolet absolute photoabsorption cross sections for vibrationally-excited triatomic molecules. The setup consists of a stainless steel absorption-cell wrapped by sheath wires of 1.2φ in diameter and 2 m length. For the first set of measurement on CO_2 in photon energy range of 10.6 – 11.8 eV, we found that the cross sections at room temperature are in very good agreement with previous measurements.

1 Introduction

The vibrational wave function of the vibratioanlly-excited molecule has a larger spatial extent than that of the vibrational-ground state. Thus, spectroscopic studies of vibrationally-excited molecules can also probe different regions of potential energy surfaces of electronically excited states. Molecules in which non-totally symmetric vibrations are excited may exhibit new properties due to symmetry breaking. Indeed the dramatically enhanced vibronic-coupling effects were clearly observed in electron impact excitation [1] reported recently as well as our x-ray absorption spectra of the vibrational excited CO_2 molecules [2]. In this work, in order to investigate the temperature effect of valence-electron excitations we have developed a setup to measure the VUV-photoabsorption cross sections of vibraiotnally-excited molecules.

2 Experiment

Measurements were performed on the 3-m normal incidence vacuum monochromator of the BL-20A beam line at the Photon Factory synchrotron facility. A 1200 lines/mm grating was used to achieve a resolution of 2 meV (FWHM) with entrance and exit slit widths of 50 μm. The newly developed setup consists of a stainless steel absorption-cell with an effective length of 220-mm wrapped by sheath wires of 1.2φ in diameter and 2 m length, a LiF window, and a photomultiplier tube with a CsI-coated photocathode assembled after the exit slit of the absorption-cell. The cell which has been newly built at Sophia University is heated from room temperature (~300 K) up to 600 K by resistive heating. Figure 1 shows the schematic diagram of such setup.

The pressure of the target molecule in the absorption-cell is monitored with a capacitance manometer (Baratron 626A, MKS Co. Ltd) kept at room temperature. The target pressure was corrected by the thermal transpiration effect with the empirical expression developed by Takaishi and Sensui [3] for each set of temperature measurements.

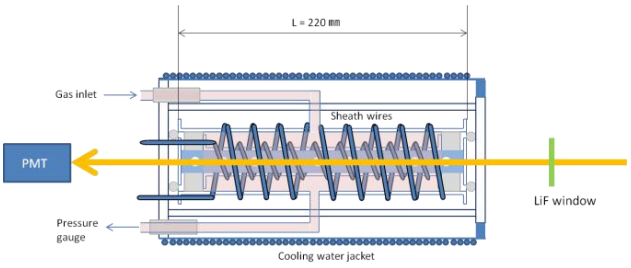

Fig. 1: A schematic diagram of the apparatus.

3 Results and Discussion

The measured absorption spectra of the target gases were converted to absolute photoabsorption cross sections by applying the Lambert-Beer law. From the first set of measurements in photon energy range of 10.6 – 11.8 eV, we found very good agreement between our cross sections at room temperature (310 K) and previous data by Stark et al. [4] at 295 K.

References

[1] N. Watanabe *et al.*, J. Chem. Phys. **138**, 184311 (2013).
[2] T. Tanaka *et al.*, Phys. Rev. Lett. **95,** 203002 (2005).
[3] T. Takaisi and Y. Sensui, Trans. Faraday Soc. **59**, 2503 (1963).
[4] G. Stark *et al.*, J. Quant, Spectr. and Rad. Trans. **103**, 67 (2007).

* masami-h@sophia.ac.jp