Laboratory Experiments of Solar Wind Charge Exchange in Soft X-Ray Spectroscopy

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The soft X-ray emission from the solar system has been understood as the result of the solar wind charge exchange (SWCX), namely the electron capture of multiply charged solar ions in collisions with neutrals within the heliosphere [1]. In the next generation of the X-ray observation satellite, it us planed to install a transition edge sensor (TES) micro-calorimeter which has good energy resolution.

In order to analyze the observed X-ray spectra with the satellites quantitatively, the cross sections of the charge exchange and photon emission processes are necessary to be measured. Therefore, we have proposed to observe the soft X-ray emission spectra in collisions of multiply charged ions with hydrogen atoms/molecules with the TES micro-calorimeter. In this work, we have observed the X-ray emission spectra in collisions between multiply charged ions with helium and hydrogen gases by using the window-less Si (Li) detector as the preliminary experiment to confirm the feasibility.

The helium-like and hydrogen-like carbon, nitrogen, and oxygen ions was produced in a 14.25 GHz electron cyclotron resonance ion source at Tokyo Metropolitan University. The ions were extracted with an electric potential of 5–20 kV, selected according to their mass-to-charge ratios using a magnet, and directed into a collision chamber. In the chamber, the ion beam intersected an effusive beam of target gas ejected from a multi-capillary plate. Optical radiation in the soft X-ray region from the collision volume was observed at 90° to both beams with the detector.

The spectrum observed in collisions of O^{8+} with H_2 at collision energy of 80 keV with the energy resolution of about 110 eV is shown in Fig. 1. The main peak is corresponding to the 1s–2p transition, and the small contributions of the 1s–3p and 1s–4p transition also are observed. According to both the classical over the barrier model and the TC-AOCC (two-center atomic orbital close coupling) calculation, the dominant capture level is $n = 4$. Therefore we indicate that the cascade from the upper states $n\ell$ makes large population in the 2p state. The relative intensities of the 1s–$n\ell$ transitions have large difference from the previous expreriments [2]. The reason of the discrepancy can not be understood even if we consider the difference in the windows of the detectors.

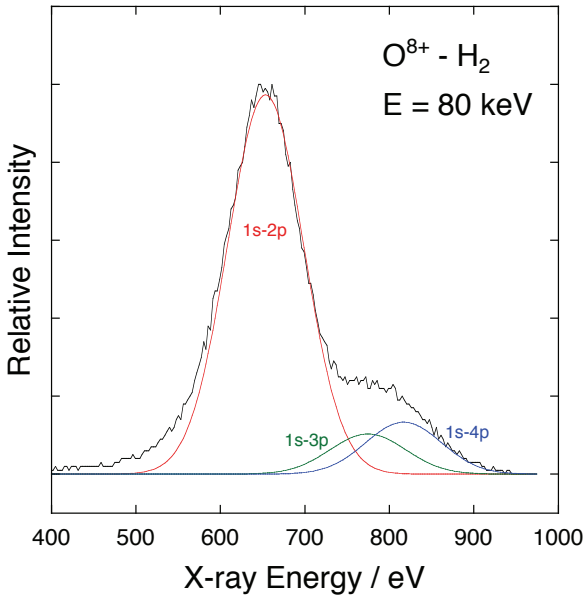

Fig. 1. Soft X-ray emission spectra in collisions of O^{8+} with H_2 at collision energy of 80 keV.

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References

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