Soft X-ray emissions related to the solar wind charge exchange observed by the X-ray satellite observatories

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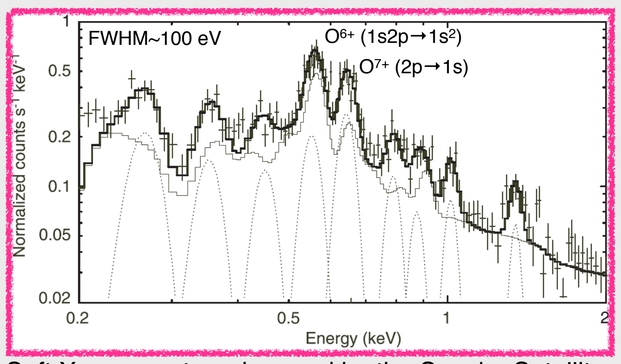
We have observed the emission spectra in collisions of bare and hydrogen-like C and O ions with helium atoms and hydrogen molecules in the soft X-ray region using a window-less Si(Li) detector at collision energies around 100 keV. It is found that the 1s-2p emission is dominant in each spectrum. We indicate that the cascade from the upper states give the large population of the 2p state after the consideration using state-selective capture cross sections calculated by the TC-AOCC method.

Introduction

The soft X-ray emission from the comets and the soft X-ray background signals observed with the X-ray satellite observatory have been understood as the transitions of the highly charged ions in the solar wind which underwent charge-exchange collisions with neutral gases in the heliosphere. To analyze future observed X-ray satellite spectra using high resolution micro calorimeter, it is necessary to know cross sections for charge exchanges.



Soft X-ray spectra, observed by the Suzaku Satellite
R. Fujimoto *et al.*, PASJ **59**, S133 (2007)

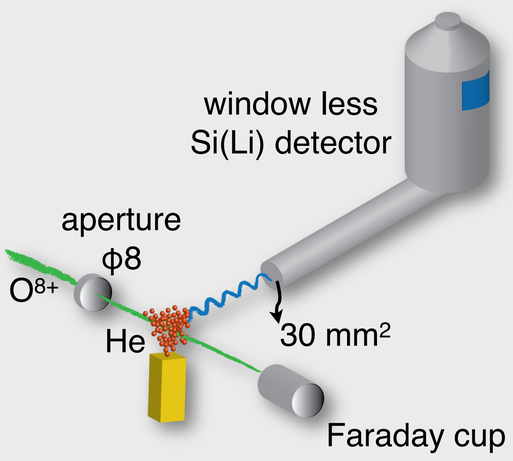
Solar Wind Charge eXchange (SWCX)

$A^{q+} + B \rightarrow A^{(q-1)+*} + B^{+}$ (↓ $A^{(q-1)+} + h\nu$) A : C, O B : H, He

The energy resolution of the detector on the present X-ray satellite is not sufficient to distinguish fine structures. So, High resolution X-ray detector is required to identify emission. We are planning experiment using high resolution, Transition Edge Sensor (TES) micro calorimeter.

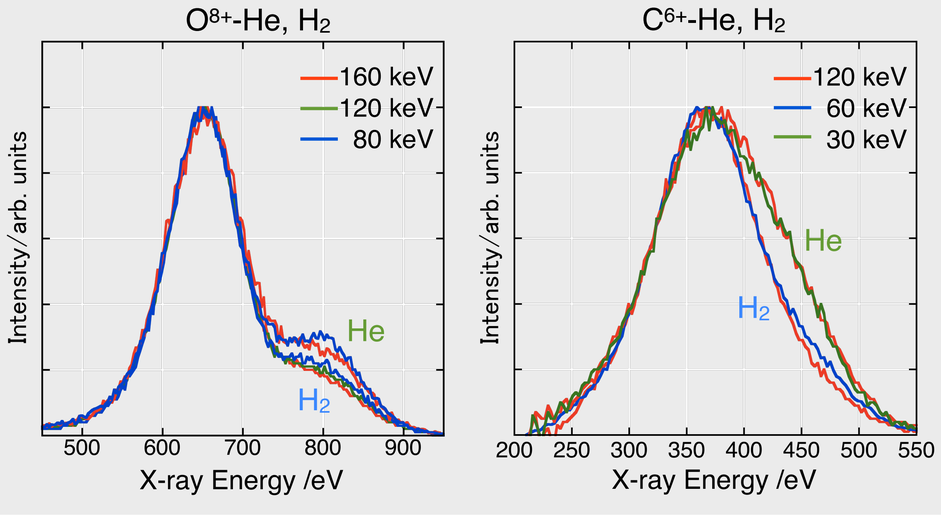
Experimental Setup

Gas jet method
The highly charged ions produced with a 14.25 GHz ECR ion source were fed into a collision chamber after the charge-state selection. Soft X-ray emission following the collisions of highly charged O and C ions with He and H_2 target gases was observed at 90° to the ion beam direction with a window-less Si(Li) detector.



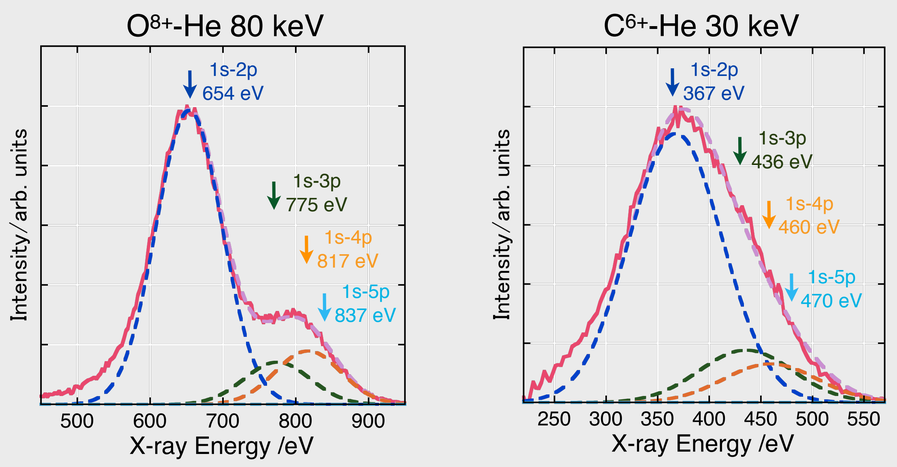
Results

emission spectra
collision energy and target dependences

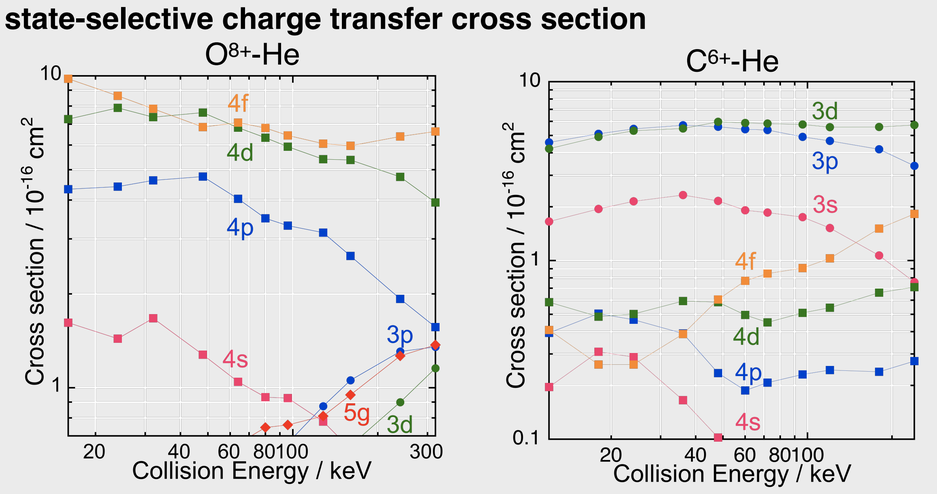


Discussion

deconvolution



Two-Center Atomic Orbital Close Coupling Calculation
state-selective charge transfer cross section



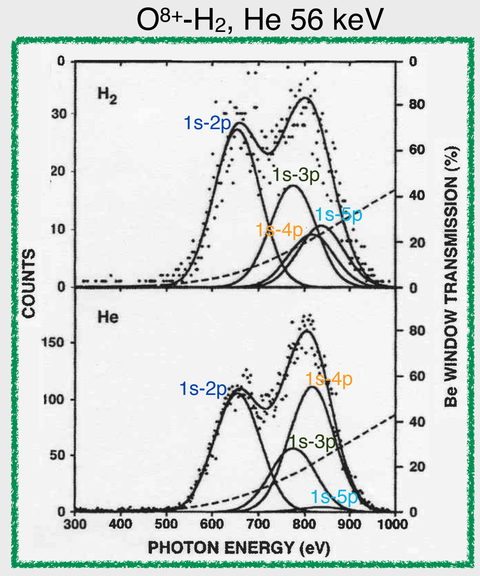
dependence
on energy : small
on target : significant

state-selective emission
O^{8+}-He : 1s-3p < 1s-4p < 1s-2p
C^{6+}-He : 1s-4p < 1s-3p < 1s-2p

FWHM : 107 eV

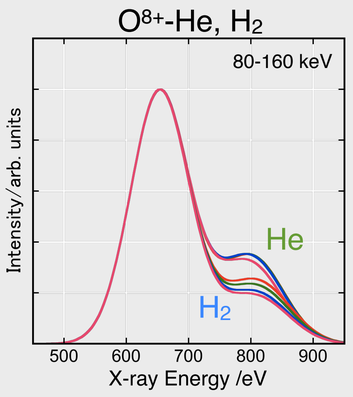
previous works

O^{8+}-H_2, He 56 keV

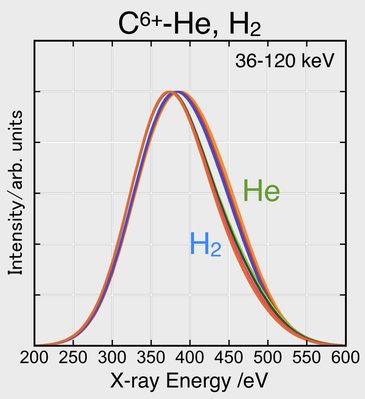


J. B. Greenwood et al., PhysScr. T92, 150 (2001)

cascade model
The relative intensities of 1s-2p, 1s-3p, and 1s-4p have been reproduced with the cascade model using the state-selective capture cross sections calculated by the TC-AOCC method.



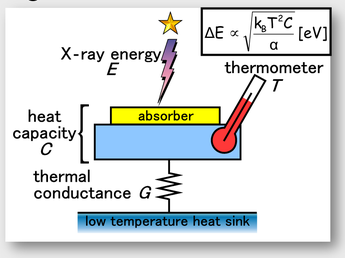
O^{8+}-He, collision energy : 80 keV		
transition	experiment	theory
1s-2p	75%	72%
1s-3p	11%	12%
1s-4p	14%	15%
1s-5p	0%	0.51%

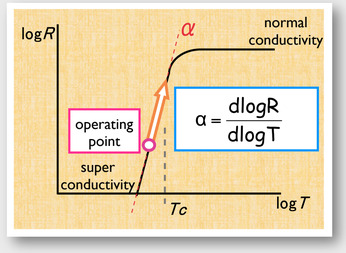


C^{6+}-He, collision energy : 30 keV		
transition	experiment	theory
1s-2p	75%	61%
1s-3p	14%	36%
1s-4p	11%	2.3%
1s-5p	0%	0.13%

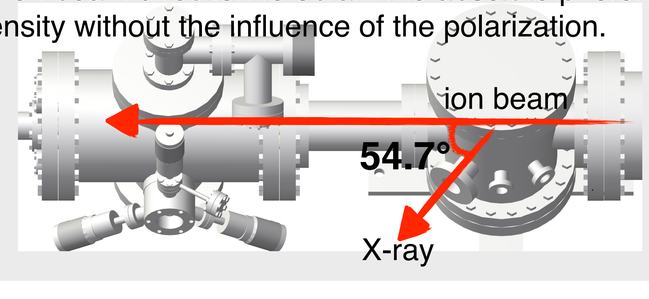
Future

Transition Edge Sensor X-ray micro-calorimeter
TES calorimeter has enough resolution (< 10 eV) to distinguish each emission line.





Magic Angle
We will observe soft X-ray emission at the magic angle to the ion beam direction to obtain the absolute photon intensity without the influence of the polarization.



Gas cell method
It's possible to measure the absolute target gas pressure. So, this set up have been designed to measure charge transfer cross sections by an attenuation method.