References

[1] L. F. Canto, et al., Nucl. Phys., A424(2006)1.
[2] N. Takigawa, et al., Phys. Rev., C47(1993)R2470.
[3] Y. Kaneda-En'yo, et al., Phys. Rev., C52(1995)628.
[4] Y. Kaneda-En'yo, et al., Phys. Rev., C52(1995)647.
[5] Y. Kanada-En'yo, et al., Phys. Rev., C60(1999)064304.
[6] Naoya Furutachi, Masaaki Kimura, et al., Theor. Phys., 122(2009)865.
[7] R. J. Charity, et al., Nucl. Phys., A483(1988)371.
[8] A. Mukherjee, et al., Nucl. Phys., A596(1996)299.

2 - 4 Fluorescence Emission from CsI(Tl) Crystal Induced by High-energy Carbon Ions and X-rays

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The thallium activated caesium iodide (CsI(Tl)) scintillationcrystalshave the advantages of high light output, little afterglow, sufficient stopping power, large detection area, and low cost. Theyhave been applied in many large solid angle detection arrays. The spatial, temporal or energy- information of the particles are probed generally by detecting the photons induced by the particles. The information is precious for both nuclear and material physics. However, there is a general lack of experimental data on spectra components and mechanism of the fluorescence emission induced by different kind of particles.

In this work, the fluorescence emission spectra from ultraviolet to visible band were measured when high energy carbon ions passing through a thin plate of CsI(Tl) crystal (CaesiumIodide doped with Thallium). The experiments were carried out at the Cooling Storage Ring of the Heavy Ion ResearchFacility at Lanzhou (HIRFL), while the sample plate was cut from the center of a big bulk of CsI(Tl) crystal made in the Institute of Modern Physics, Chinese Academy of Sciences.

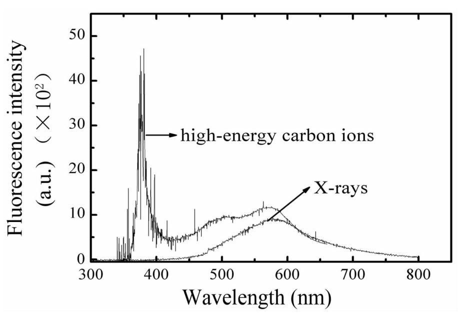

Fig. 1 The fluorescence emissionspectra of the CsI(Tl) crystal induced by high-energy carbon ions and X-rays.

Fig. 1 shows that the fluorescence emissionspectra of the CsI(Tl) crystal induced by high-energy carbon ions and hard X-rays. It is found that the visible band is centered at around 570 nmwas observed in excitation of the high-energy carbon ions and X-rays. However, the ultraviolet-band (around 377 nm) emission, which is attributed to the electronic transitions from trigonal and tetragonal Jahn-Teller minima of the triplet relaxed excited state of Tl^{+} [1], is a characteristicemission from the high-energy carbon ions. The intensity of the band is very high, and the peak is very sharp (with a full width at half maximum (FWHM) of about 12 nm, which is about five times lower than that of the visible-band emission). Due to that the ionization density induced by high energy heavy ions is muchlarger than that induced by X-rays or γ-rays, the characteristic emission from 0.15 mol% Tl-dopedCsI(Tl)) crystal could be observed[2,3]. Simultaneously, this is also the reason that the characteristic emission with central wavelength around 500 nm from the very low fraction of the crystal defects was observed as well in case of heavy ion impacting.

That the ultraviolet-band (around 377 nm) emission is only observed in the excitation of high energy ions is very important for the CsI(Tl)) scintillation as a particle detector. It can help to accurately detect the spatial, temporal or energy information of high energy particles by only obtaining the ultraviolet-band emission.

References

[1] V. Nagirnyi, S. Zazubovich, V Zepelin, et al., Chem. Phys. Lett., 227(1994)533.

[2] M. M. Hamada, F. E. Costa, M. C. C Pereira, et al. , IEEE Transactions on Nuclear Science, 48(2001)1148.
[3] P. Schotanus, R. Kamermans, P. Dorenbos, IEEE Transactions on Nuclear Science, 37(1990)177.
[4] R. Hofstadter, H. Grassmann, H. G. Moser, Nucl. Instr. and Meth. , A228(1985)323.

2 - 5 Charge State Effect on Si K X-ray Emission Induced by I^{q+} Ions Impacting

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The interaction mechanisms of highly charged ions and atoms have been extensively investigated and have the potential for surface characterization and material modification[1]. The charge state effect on K-shell ionization of Al target irradiated by Xe^{q+} (q=12～29) ions has been explained by using the molecular orbit transition mechanism in the velocity regime below the Bohr velocity[2]. However, near the Bohr velocity, there is a general lack of the charge state effect in the highly charged heavy ion-atom collisions.

In the present work, Si K X-ray emission spectra induced by I^{q+} ions were measured. The experiment was performed at the 320 kV ECR Platform for Highly Charged Ion Beam in Heavy Ion Research Facility in Lanzhou (HIRFL). The X-rays are detected with a Si Drift Detector (SDD), which has a detective area of 7 mm^2 in the front of the detector.

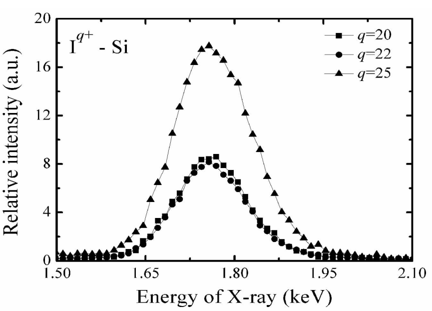

Fig. 1 The typical X-ray spectra induced by I^{q+} (q=20, 22, 25) ions.

Fig. 1 represents the typical X-ray spectra induced by 3. 0 MeV I^{q+} (q=20, 22, 25) ions impacting on Si target. It is found that, the only K X-ray of the target was observed, and the peak position did not change with the variation of the charge state of incident ions. In addition, it is obvious that the relative intensity of Si K X-ray induced by I^{25+} ions is larger than that by I^{20+} and I^{22+} ions. While for I^{20+} and I^{22+} impacting, the relative intensity of X-ray emission is almost equal.

In our experiment, comparing to I^{20+} and I^{22+} ions, the 3d vacancies of I^{25+} ions are more easily produced by quasi-molecular transition in the interaction of projectile ions and target atoms, since the 3d energy level of I^{25+} ions is more close to 1s energy level of Si atom[3]. In other words, the number of 3 d vacancies of I^{25+} ions is more than that of I^{20+} and I^{22+} ions during the interaction. Thus, the transfer probability of 3 d vacancies of projectile to the 1s orbital of target for I^{25+} ions is larger than that I^{20+} and I^{22+} ions basing on the molecular orbit (MO) model[4]. That transfer arises from rotational coupling of 3dπ, δ-3dσ atom quasi-molecule. The increase of the transfer probability may make a considerable contribution to the enhancement of ionization of Si atoms induced by I^{25+} ions.

Further calculation on the phenomena will be carried out in the future.

References

[1] A. S. El-Said, et al. , Phys. Rev. Lett. , 100(2008)237601.
[2] Y. Song, et al. , Eur. Phys. J. , D64(2011)197.
[3] P. H. Mokler, et al. , J. Phys. , B17(1984)4499.
[4] M. Lichten, et al. , Phys. Rev. , 6(1972)211.