Continuum X Rays of 10-70 keV form Carbon Thick-Target Bombarded by 3 MeV Protons

I. 12. Continuum X Rays of 10-70 keV from Carbon Thick-Target Bombarded by 3 MeV Protons

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By bombarding a solid or gaseous target with heavy charged particles of heavy ions, continuum x rays are produced. We can find a structure of strata in the spectra of continuum x rays; in the region of x-ray energy $\hbar\omega < T_r$ ($=\frac{1}{2} m_e v_p^2$, m_e is the rest mass of electron and v_p is the velocity of projectile), the quasi-free electron bremsstrahlung is a predominant process, the secondary electron bremsstrahlung in the region of $T_r < \hbar\omega < T_m$ ($= 2m_e v_p^2$) and the atomic bremsstrahlung in the region $\hbar\omega > T_m$.[1] In addition to these continua, the radiative electron capture x rays[2] and the molecular orbital x rays[3] can be observed in the heavy ion bombardments. The atomic bremsstrahlung is a main component in the region of high energy x-rays. However, for higher energy the nuclear bremsstrahlung becomes important.

The nuclear bremsstrahlung is produced by collisions of the projectile nucleus and a target nucleus. The atomic bremsstrahlung and the secondary electron bremsstrahlung rapidly decrease with increase in the x-ray energy, while the nuclear bremsstrahlung slowly decreases with the energy dependence of $1/\hbar\omega$.[4]

For the study of nuclear bremsstrahlung in ion-atom collisions, a carbon target 5 mm thick was bombarded with 3 MeV protons. The continuum x rays produced by the carbon target were measured at the angles of 0°, 45° and 90° with respect to the beam direction. The carbon target was selected by the reason of low backgrounds of γ-rays produced by the nuclear Coulomb excitation and was used the Si(Li) detector which is not so sensitive for high energy γ-rays. The experiment was performed with a large solid angle ~10^{-2} sr.

In Fig. 1, the yields of continuum x rays are plotted for the emission angles of 0°, 45° and 90°. Here, the x-ray yields as not corrected by the self-absorption, the absorption by an aluminum window 0.8 mm thick and the detector efficiency. The pile up effect caused by the high counting rate of lower energy x rays was reduced with the x ray absorption by the target itself and the Al window. The continuum x rays were measured over the energy

range from 10 keV to 70 keV. The isotropic angular distribution of continuum x rays was obtained, however, the theory[4] predicts an angular dependence on the cross sections. The solid line shown in Fig. 1 is the calculations of nuclear bremsstrahlung based on the isotropic assumption.[4] According to the present results, it is supposed that the incident beam is defocused by straggling in the target and this effect gives rise to isotropic distribution of nuclear bremsstrahlung.

References

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4) Ishii K., Sera K., Orihara H. and Morita S., Proceedings of the 7th Symposium on Ion Beam Technology, Hosei University, December 9-10, 1988, 187.

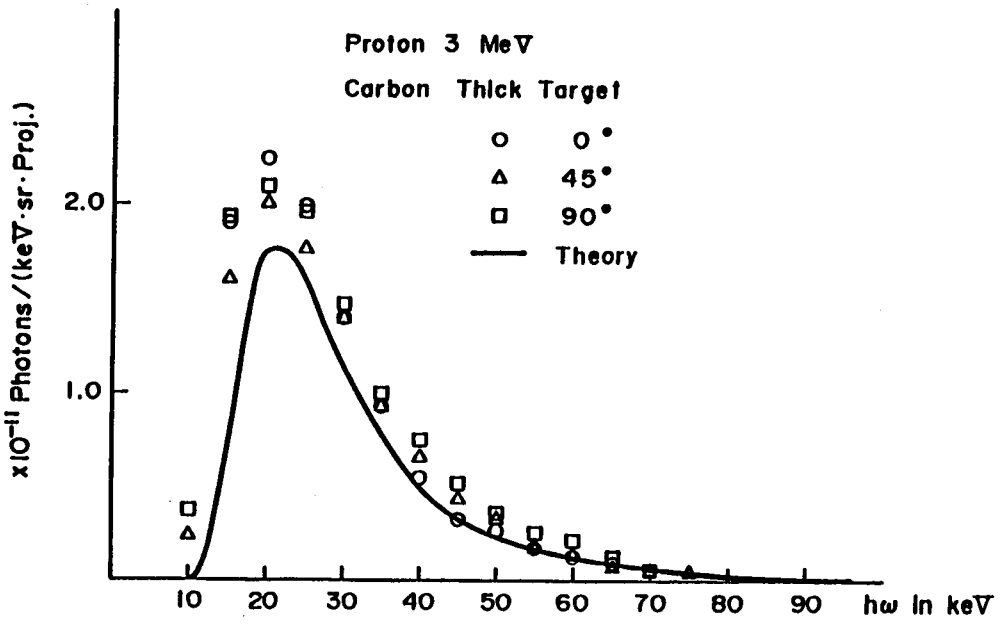

Fig. 1. The yields of continuum x rays from the carbon thick target bombarded with 3 MeV/amu protons.