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Combination of Compton spectrometer and CCD camera for XRF experiments

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Introduction

Recently, the authors employed a Compton spectrometer (NE1A1) [1] to measure Kβ X-ray fluorescence (XRF) from lanthanides. In this case, both the measuring time and the energy resolution are mainly restricted by the performance of the imaging plate (IP). This report describes preliminary tests using a CCD camera as a detector for this spectrometer.

Experimental

As shown in Fig.1, a CCD camera (576×384 pixels, pixel size 22μm×22μm, equipped with fiber optics and a Gd_2O_2S:Tb scintillator, Peltier cooling -30°C, Princeton Instruments, Inc.) was attached to the Compton spectrometer. Since there are several pairs of Si(422) crystal analyzers and vacuum pipes (ca. 2.5m), an IP (BAS-III, Fuji Film) is also used for the comparison. The scanner used is a BAS-2000 system and the smallest pixel size is 100 μm×100 μm. The energy of the primary beam is 70 keV.

Results

Typical XRF spectra measured by an IP and a CCD camera are shown in Figs 2(a) and (b), respectively. The sample measured is Gadolinium metal (pellet of 10 mm dia., 5 mm thickness), and the figures show Gd Kβ spectra. One can see that CCD data (b) was obtained in only 4 min, while the IP data (a) required 110 min. The statistics are still not sufficient and therefore weak $K\beta_5$ is not visible, but first appearances are not bad. It is possible to obtain such spectra in just minutes, and energy resolution is better than IP data because of the rather small pixel size.

The problem with the CCD experiment is that the signal to background ratio is not so good as expected. First, this CCD camera system is more suitable for a smaller spectrometer. The present spectrometer is designed for Compton scattering experiments requiring simultaneous collection in the 40-60 keV region, but the present CCD camera is not large enough to cover so wide an energy range. When the necessary range is only 2~3 keV as shown in Fig.2 (b), more efficient experiments will be possible by employing a different type of spectrometer. Second, a possible imperfection of the shielding against the high-energy X-ray background is a problem. In summary, the use of a CCD camera instead of IP is a possible solution to enhancing both sensitivity and energy resolution. The authors would like to thank Professors H. Kawata and N. Shiotani (KEK-PF) for their kind cooperation.

Reference

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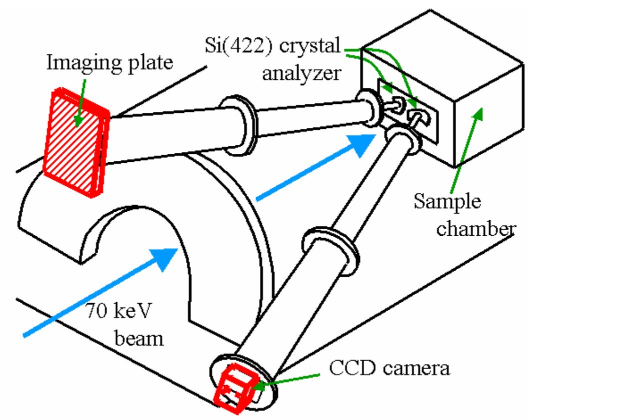

Figure 1 (top). Experimental layout. The position of the CCD camera is adjusted by a stepping motor.

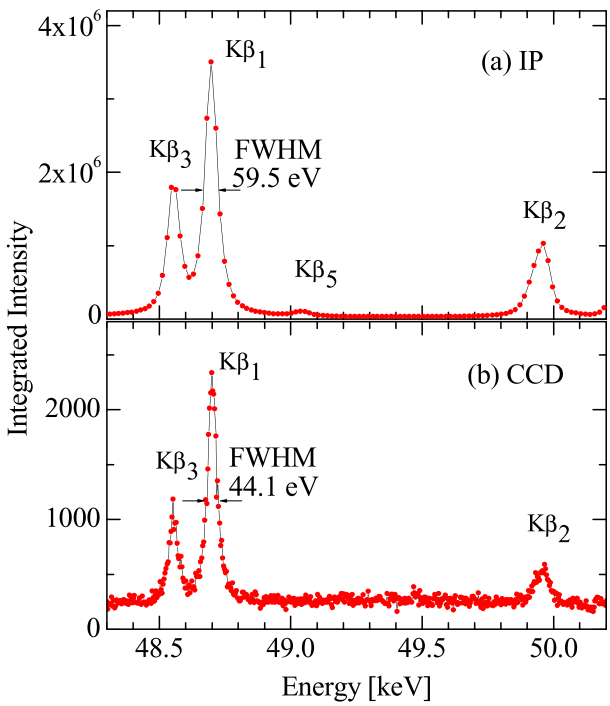

Figure 2 (right). Kβ spectra of Gd metal: (a) IP, (b) CCD. Measuring time is very different at 110 min and 4 min for IP and CCD, respectively. The number of pixels summed over the vertical direction was 600 and 384 pixels for IP and CCD, respectively. The background image caused by the dark current was subtracted from the CCD data before integration.