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Calibration method for contrast reduction problem in the X-ray image-intensifier

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Introduction

CCD-based X-ray detectors [1] coupled with the beryllium-windowed X-ray image-intensiÞers (Be-XRII) have been used for time-resolved X-ray diffraction/scattering studies. Especially, small-angle X-ray scattering (SAXS) experiments are main application of the detector. These detectors have image distortions and non-uniformity of response due mainly to the convex shape of the entrance beryllium window of the Be-XRII and due partially to parallax of the electrostatic lens of the Be-XRII including the inßuence of surrounding magnetic Þeld. The non-uniformity of response of the detectors originates from inclined X-ray incidence against the phosphor surface of the Be-XRII owing to its convex shape, and pixel-size non-uniformity resulting from the image distortion. We have developed the calibration method of the non-uniformity of response by using the Imaging Plate (IP) as a reference. However, it has been found that the calibration for the image distortion and non-uniformity of response alone is not sufÞcient when the intensity ranges of the images are more than two orders of magnitudes. In Ref. [2], they pointed out the limited dynamic range of the Be-XRII.

Contrast reduction

This discrepancy originates from the phenomenon of so-called "contrast reduction" of the Be-XRII, in which spurious intensities are recorded even at a region where x-rays are not incident. The spurious intensity distribution depends on the overall intensity distribution, because small portions of the intensities from all over the region contribute to spurious intensity at a region of interest. An example of the contrast reduction is shown in Fig. 1. The plot "2" in Fig. 1 is obtained behind a lead mask which is placed in front of the detector. In principle, no signal have to be observed behind the mask. This is the contrast reduction problem of the Be-XRII.

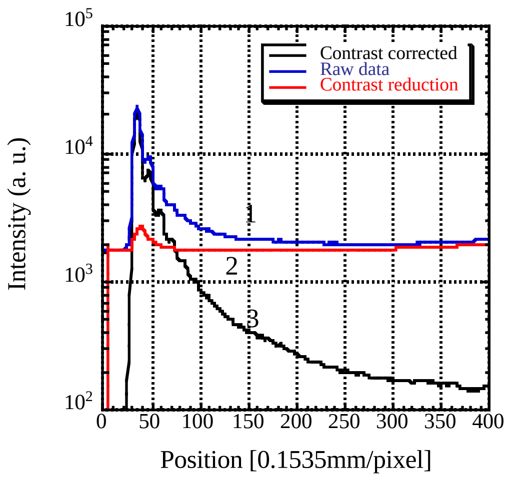

Fig. 1: An example of the "contrast reduction"; 1) raw data, 2) contrast reduction, and 3) corrected data.

Experimental result and discussion

A test experiment is done in the BL-15A. The sample is the PS latex solution. The scattering patterns taken by the PSPC and the CCD-based X-ray detector is shown in Fig. 2. The scattering pattern taken by the CCD-based X-ray detector is corrected the contrast reduction by using a fan-shaped mask in front of the detector. The calibration method of the contrast reduction is very simple. Only the signal behind the fan shape mask is subtracted from the raw data. In Fig. 2, both scattering patterns are well coincided till the higher angle region. Therefore, the calibration method of the contrast reduction in the Be-XRII is working well.

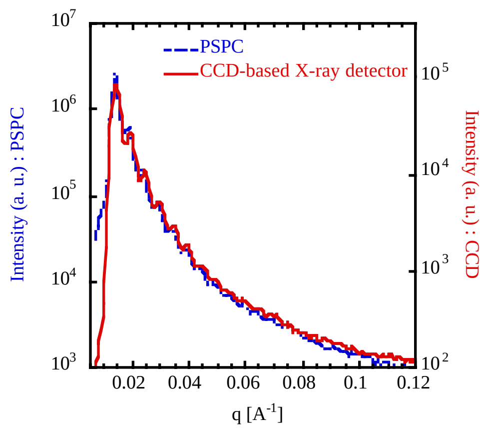

Fig. 2: The scattering patterns of the PS latex solution taken by the PSPC and the CCD-based X-ray detector.

Conclusion

We have successfully resolved this problem in the case where the scattering patterns are center-symmetric by placing a fan-shaped mask in front of the Be-XRII and thereby precisely estimating the center-symmetric spurious intensity distribution. As results, the X-ray scattering patterns from solution can be calibrated well enough over more than three orders of magnitudes.

Several applications of this calibration have been already studied, especially the small-angle X-ray solution scattering and etc.

References

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