Development of a new X-ray magnetic diffraction method using a long period of magnetic field reversal
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Introduction
X-ray magnetic diffraction (XMD) experiments on BL3C have been performed by using a short period, typically 10s, of magnetic field reversal to measure magnetic effect (flipping ratio) of diffraction intensities. This was because we have needed to compensate monotonic decrease of synchrotron radiation intensity. Recently the Photon Factory storage ring started top-up operation (April 2009), and the incident X-ray intensity has come to be almost constant. In this study we try a longer period of magnetic field reversal. This study will lead to the XMD experiment using a superconducting magnet that produces magnetic field of the order of ten tesla but needs long magnetic-field reversing time.

Experiments
First we modified the XMD measurement program that controls the experimental sequence for accepting various periods of magnetic field reversal. We made the XMD experiment of two samples. One was a pure Fe crystal and the other was a Fe$_3$Pt crystal. We measured the flipping ratio of diffraction intensities of (110) and (221) reflection plane for Fe and Fe$_3$Pt, respectively. The period of magnetic field reversal was 10s, 50s, 250s and 1000s.

Results and Discussion
The observed flipping ratios of Fe and Fe$_3$Pt are shown in Fig. 1 and Fig. 2, respectively. In these figures the flipping ratios of fluorescence intensities are also shown, which are expected to be much smaller in magnitude and much closer to zero than those of diffraction intensities. Miller indices of the diffracted X-rays are 220, 330, 440 and 550 for Fe, and 221 and 442 for Fe$_3$Pt. Fluorescence X-rays are FeK$_\alpha$ and FeK$_\beta$ for Fe sample and FeK$_\alpha$, FeK$_\beta$, PtL$_\alpha$ and PtL$_\beta$ for Fe$_3$Pt sample. In Figs. 1 and 2 it is noted that the data points of 1000s deviate largely from the others. Especially the fluorescence data are shifted from zero, which infers variation of the incident X-ray intensity.

We tried to correct the spectrum data so as that the flipping ratio of fluorescence X-rays of FeK$_\alpha$+K$_\beta$ for Fe and PtL$_\alpha$ for Fe$_3$Pt is zero. The corrected flipping ratios of the diffraction data for Fe and Fe$_3$Pt are shown in Figs. 3 and 4, respectively. In Figs. 3 and 4 it is noted that the flipping ratios for 10s, 50s, 250s and 1000s agree within the statistical errors.

In conclusion, we have successfully performed the XMD experiment using a long period, 1000s, of magnetic field reversal by correcting the spectrum data so as that the flipping ratio of the fluorescence X-rays is zero. This result will lead to a new XMD experiment using a superconducting magnet.

Fig. 1 Observed flipping ratio of Fe.
Fig. 2 Observed flipping ratio of Fe$_3$Pt.
Fig. 3 Corrected flipping Ratio of Fe.
Fig. 4 Corrected flipping ratio of Fe$_3$Pt.