Development of A Monochromatic Beam Method of X-ray Magnetic Diffraction with A Phase Plate and A Linear Polarizer

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Nonresonant X-ray magnetic diffraction is a unique tool which can separate magnetic form factors of ferromagnets into the spin- and the orbital-moment parts. This method utilizes elliptically polarized X-rays, and a magnetic effect is measured which is a change in diffraction intensity caused by magnetization reversal. The problem of this method is that the magnetic effect is small (of the order of 0.1%) due to weak interaction of photons with magnetic moments and that accurate measurement of the spin- and the orbital-magnetic form factor is difficult. The aim of this study is to develop a new method to enhance the magnetic effect, which will facilitate accurate measurement of magnetic form factors of ferromagnets by X-rays.

The points of this method are: (1) 3rd generation synchrotron radiation from an undulator which is quite brilliant and highly linearly polarized, (2) a linear polarizer which increases the degree of linear polarization, and (3) a transparent-type phase plate which produces elliptically polarized X-rays out of linearly polarized X-rays. This method enhances the polarization factor, $f_P=P_c/(1-P_l)$, which is proportional to the magnetic effect, where P_l and P_c are the degree of linear and circular polarization of the radiation incident on a specimen.

The experiment was made at BL39XU, where a Si(111) double-crystal monochromator and a phase plate of a diamond crystal are equipped. We set a linear polarizer of Si(333) double crystals in front of the phase plate. The diamond crystal was 0.7mm thick (111)-oriented slab and the (220) diffraction plane was used. A pure iron single-crystal specimen was set at the center of the diffractometer, and magnetized with an electromagnet along the direction perpendicular to the incident X-rays. We measured the magnetic effect R of the intensity of 220 diffraction with the 90° scattering angle as a function of $\Delta\theta$ which is an offset angle from the Bragg condition at the phase plate crystal.

The observed curve of R vs. $\Delta\theta$ in the figure shows that the magnetic effect is largely enhanced and amounts to 10% which is the largest ever achieved.