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Magnetic properties of single-crystalline Fe_2P under multi-extreme environments studied by ^{57}Fe nuclear forward scattering

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Introduction

At ambient pressure, Fe_2P has a hexagonal crystal structure, which has two different Fe sites. The ferromagnetic phase transition takes place at T_C=200K with large volume increase. The magnetic moments of two Fe sites were obtained to be 0.92 and 1.70 μ_B at 77 K by neutron diffraction[1]. A pressure-induced transition occurs from the ferromagnetic to an antiferromagtic states at about 1.5GPa and 12K. Furthermore, a metamagnetic transition was observed in the antiferromagnetic state when the magnetic field was applied along [0001]. These pressure and magnetic field induced phase transitions were tried to be explained by the itinerant electron model[2]. Meanwhile, we have no precise knowledge of magnetic structures of Fe_2P under multi-extreme environments.

Experimental

^{57}Fe nuclear forward scattering (NFS) experiments were performed at beamline NE3 in the accumulation ring. The pulsed SR was monochromatized by a high-resolution monochromator. The monochromatized x-ray transmitted through the sample was detected by three Si-avalanche photodiodes.

Under high pressure, the single-crystalline Fe_2P sample was loaded with ruby crystals into a sample cavity of inconel 625-alloy gasket. The use of Fluorinert as a pressure-transmitting medium ensured quasihydrostatic conditions. Pressure was calibrated by measuring the wavelength shift of R_1 luminescence line of the ruby crystals in a clamp-type diamond-anvil-cell (DAC).

External magnetic fields (H_{ex}) were applied to the sample in DAC using a superconducting magnet where the H_{ex} direction is parallel to the propagation vector of SR and the [0001] of the sample.

Results and Discussion

Figure1 shows the external magnetic field dependence of ^{57}Fe NFS spectra at 2.5 GPa and 3.5 K up to 65 kOe. The features of ^{57}Fe NFS spectra above 5 kOe are much different from that without H_{ex} as seen Fig. 1. This result reveals that the magnetic field-induced transition occurs below 5 kOe, which consist with a recent result of magnetization measurements under pressure[3].

The data analysis was performed with MOTIF[4] by using the full dynamical theory of unclear resonance scattering. All observed ^{57}Fe NFS spectra were fitted using two different sets of hyperfine interaction parameters as seen in Fig. 1. Accordingly, two Fe sits have deferent magnetic moments in the antiferromagtic state. In this analysis, we have deduced the value and the direction of magnetic hyperfine field because we have measured ^{57}Fe NFS spectra using the single-crystalline sample. The magnetic structure above 5 kOe is not simple ferromagnetic one. The internal field direction of one Fe site is aligned along the H_{ex} direction above 50 kOe while that of the other Fe site maintains 20 deg. relative to the H_{ex} direction up to 65 kOe.

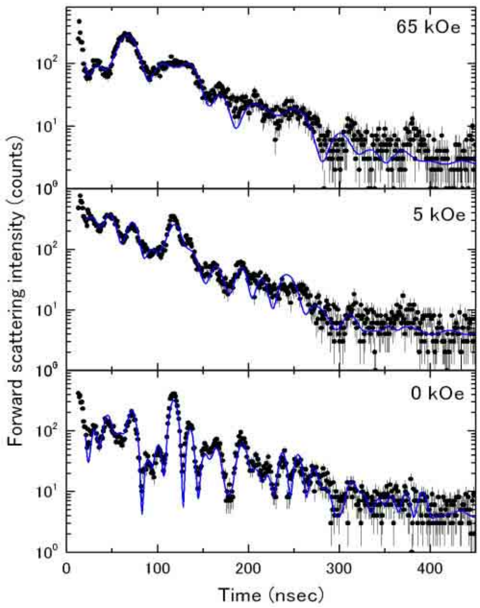

Figure 1: ^{57}Fe NFS spectra at 2.5 GPa and 3.5 K with H_{ex}

References

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