

Nuclear Resonant Small-Angle Scattering of Nanoparticles

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Introduction

The nuclear forward scattering (NFS) is powerful technique to measure the hyperfine fields of the nuclear. On NFS measurement, we can use the X-ray optical technique. It is the advantage over the other hyperfine field measurement techniques. On this study, we used small-angle scattering technique with NFS. From the nuclear resonant small-angle scattering, we can obtain the information of the hyperfine field from the specific size scattering material [1].

Experimental Procedure

The experimental arrangement is shown in Fig. 1. It is typical setting of Bonse-Hart camera. The energy of the synchrotron radiation was tuned into 14.4 keV and monochromatized into 6.4 meV width by the high-resonance monochromator. The angular profiles were measured by the rotation of second Si111 crystal. The photons were detected by the Avalanche Photo Diode (APD), which is fast X-ray detector.

The sample was magnetic fluid, which is a mixture of Fe_3O_4 nanoparticles and oil. The diameters of the particles were not controlled, so they were uneven, 10~200 nm. The Fe was enriched by ^{57}Fe . At the measurement, the sample was cooled at 80 K.

Results and Discussion

The observed time spectra are shown in Fig. 2. The small-angle spectrum is observed at 40 μrad from the forward. The small-angle scattering at this angle is probably due to 100~200 nm particles. Both spectra show same lifetime and quantum beats having same period. We estimate the different lifetime between forward scattering and small-angle scattering. The small particles have fluctuation of magnetic moments different

from particles sizes (superparamagnetism). The fluctuation of the magnetic moment decreases coherency of nuclear scattering, thus we expect the lifetime on spectra to decrease. However, on these spectra, the decrease of the lifetime is not observed.

References

[1] Yu. V. Shvyd'ko et al., Phys. Rev. B, 54, 14942 (1996).

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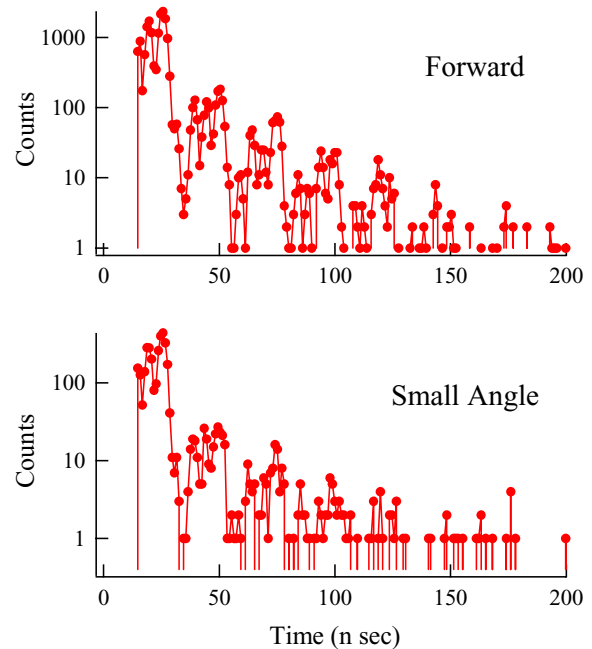


Fig. 2. Time spectra of Fe_3O_4 nanoparticles at 80K.

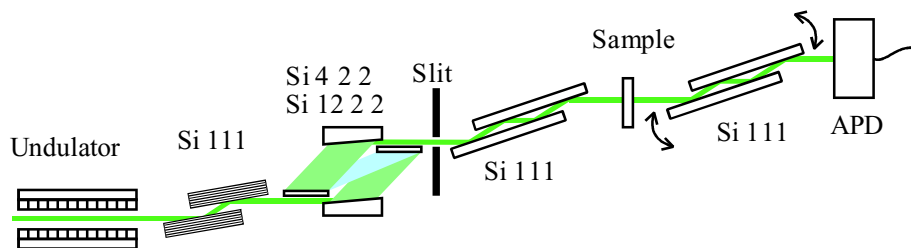


Fig. 1. Schematic drawing of experimental arrangement. Components are not in scale.