Observation of superparamagnetic fluctuations in magnetic ferrofluid using MIEZE spectroscopy

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We have developed a MIEZE(Modulated IntEnsity by Zero Effort) spectrometer at C3-1-2-2(MINE1) port JRR-3M in order to install it to the high flux pulsed neutron source at J-PARC in the near future. In the MIEZE spectrometer the sample is placed after the analyzer and there are no optical components between sample and detector. When we measure NSE and NRSE signals on paramagnetic and ferromagnetic samples the maximum contrast is reduced to 0.5 or less. On the other hand the contrast of a MIEZE signal can be observed with almost 100 % contrast(1) even in magnetic scattering because the sample is placed after the analyzer. MIEZE signal is sensitive for dispersion of neutron trajectories from sample to detector. In other words MIEZE signal is reduced due to the dispersion alone even without in- and quasi-elastic scattering. We studied the correlation between experimental configuration and its resolution function using Monte Carlo simulation. We prepared a magnetite ferrofluid sample and examined the simulation model by experiments. The experimental results were reproduced with the simulation [1]. We studied dynamical structure-changes of the magnetite ferrofluid by using the MIEZE spectrometer. The ferrofluid consists of magnetite particles and solvent (heavy water). The magnetite particles with a diameter in the order of 10 nm are coated by oleic acid. There are two kind of dynamic modes in ferrofluid. One is diffusion of magnetite particles and the other is superparamagnetic fluctuation. When we observe the superparamagnetic fluctuation, we have to measure spin-flip scattering from magnetite particle. The intensity of magnetic scattering is much smaller than nuclear scattering and separate spin-flip and non-spin-flip scattering. Thus we placed second analyzer after sample in order to observe spin-flip scattering only. The second analyzer is transmission geometry magnetic supermirror to keep trajectories of scattering neutron. Figure 1 shows typical MIEZE signals with nuclear and spin flip(magnetic) scattering at Q=0.68 nm^{-1} at room temperature. As shown in Fig.1, the contrast of MIEZE signal with magnetic scattering reduced and we succeeded in observing superparamagnetic fluctuation.

[1] H.Hayashida, et al., *Measurement Science and Technology* (2008), in press.

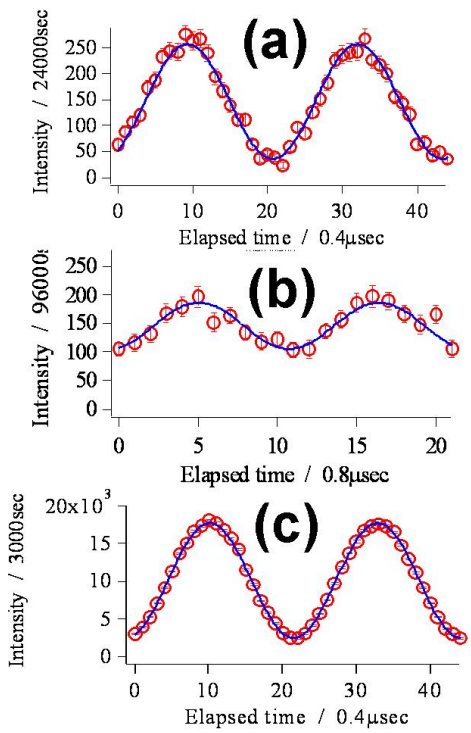

Fig. 1. Fig.1 Measured MIEZE signal(Q=0.68nm^{-1}) with (a) nuclear and (b) magnetic scattering in magnetic ferrofluid. (c) Measured MIEZE signal without sample.