Neutron spin echo measurements on the iron-based ladder compound BaFe2Se3

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Since its discovery, research on iron-based superconductivity (SC) has become the main stream in condensed matter physics. To gain further insight into the mechanism of SC and variation of magnetism, investigation of Fe-based compounds over distinct spatial dimensions is important. This is because the dimensionality strongly influences magnetism and can control itinerancy of electrons by changing Fermi surface topology.

We have examined magnetism of Fe-based ladder compounds AFe_2X_3 (A = Rb, Cs, Ba; X = S, Se) [1,2], and found the first SC [3]. This is known as the one-dimensional analogue of the Fe-based superconductors. As for parent compounds of the Fe-based superconductors, this family shows 3D magnetic ordering. However, anomaly at the magnetic transition is not visible by bulk properties. Only neutron diffraction can determine transition temperature. Here we concentrate on $BaFe_2Se_3$. We have determined block-type magnetic structure below $T_N = 255$ K through powder neutron diffraction [1]. Magnetic moments (2.8 μ_B at 5 K) are arranged to form an Fe_4 ferromagnetic unit perpendicular to the ladder direction, and each Fe_4 block stacks antiferromagnetically. However, Moessbauer experiment by our collaborators concludes that there is no anomaly at T_N, and hyperfine splitting due to the magnetic transition appears 230 − 240 K. Even below those temperatures, there is a gradual formation of magnetic ordering, and it finally falls into the ordered state $\sim$ 10 K, being consistent with hindered entropy release evidenced by the specific heat data. This distinct behavior could be originating from the difference in timescale of the experimental technique; neutron has 10^{-13} to 10^{-12} sec timescale, being faster than Moessbauer (10^{-7} sec). It should be possible to trace temperature evolution of spin dynamics with the neutron spin echo technique.

Neutron spin echo experiment was carried out on NGA NSE at NCNR, NIST. The wavelength of neutrons was set to 6 and 5 A, and data were taken at $Q = 0.73$ A^{-1} for $5 < T < 250$ K. Echo-mode measurements were performed between Fourier time 0.008 and 17.45 nsec with utilizing " shorty " mode. Relaxation behavior in intermediate scattering function is not so visible, only gradual elevation appears. Figure 1 summarizes averaged intermediate scattering function as a function of temperature. Volume fraction of spins fluctuating faster than measured Fourier time scale changes over wide temperature regime. Combining with other neutron and muon data, quantitative understanding of dynamic magnetism of $BaFe_2Se_3$ is now under way.

[1] Y. Nambu *et al.*, Phys. Rev. B **85**, 064413 (2012). [2] F. Du *et al.*, Phys. Rev. B **85**, 214436 (2012). [3] H. Takahashi *et al.*, Nat. Mat. **14**, 1008 (2015).

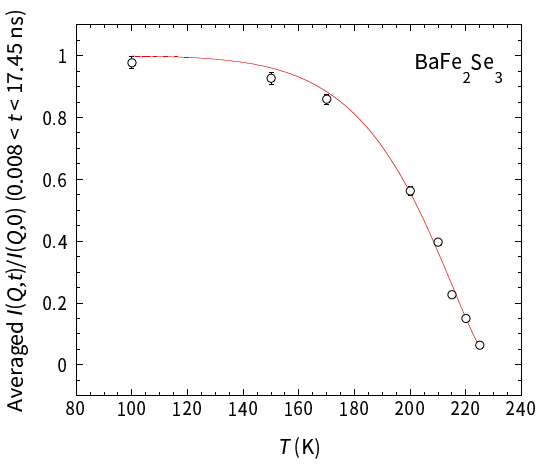

Fig. 1. Averaged intermediate scattering function of BaFe2Se3 as a function of temperature