Neutron spin echo study on the iron-based ladder compound $BaFe_2S_3$

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Since the discovery, research on iron-based superconductivity (SC) has become the main stream in condensed matter physics. The interplay between structure, magnetism and SC is one of most intriguing subjects of this field. 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) [1-3]. This is known as the one-dimensional analogue of the iron-based superconductors, and we have recently found the first SC in $BaFe_2S_3$ [3]. As for parent compounds of the 2D Fe-based superconductors, this 123 family shows magnetic long-range ordering. However, anomaly at the magnetic transition is invisible by bulk properties. Only neutron diffraction can determine the transition temperature. For $BaFe_2S_3$, we have clarified stripe-type magnetic structure and $T_N = 119$ K through powder neutron diffraction [3]. Magnetic moments (1.2 μ_B at 4 K) are arranged to form ferromagnetic units along the rung direction, stacking antiferromagnetically along the ladder direction.

However, collaborative Mössbauer experiment concludes that there is no clear transition at $T_N = 119$ K. Instead, there is a gradual formation of magnetic ordering, and it finally falls into the completely ordered state at 9 K, being consistent with the hindered entropy release evidenced by the specific heat data [3]. This 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 Mössbauer (10^{-7} sec). It should be worth tracing temperature evolution of spin dynamics through the neutron spin echo technique, whose time resolution spans from 10^{-12} to 10^{-8} sec.

Neutron spin echo experiments was performed on the NGA NSE at NCNR, NIST. The incident neutron wavelength was set at $\lambda = 5.0$ Å, and shorty setup was also adopted. Data taken at 3.6 K was used as the instrumental resolution.

Figure 1 shows temperature dependence of the intermediate scattering function (ISF). The ISF shows some relaxation behavior at longer timescale and elevation of the averaged ISF as a function of temperature. This may be interpreted as the volume fraction of spins with slower dynamics beyond the given Fourier time. Together with other neutron and muon data, quantitative analysis of the dynamical magnetism in $BaFe_2S_3$ will be discussed.

[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).

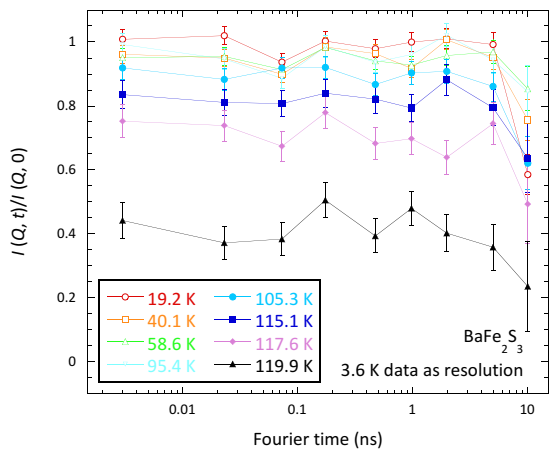

Fig. 1. Fourier time dependence of the intermediate scattering function.