Inelastic neutron scattering study in the triangular antiferromagnet $NaErSe_2$

Gaoting Lin[1], Zheyuan Liu[2], Takatsugu Masuda[2], and Jie Ma[1,2,3]

1. *Key Laboratory of Artificial Structures and Quantum Control, School of Physics and Astronomy, Shanghai Jiao Tong University, Shanghai 200240, China*
2. *ISSP, the University of Tokyo, Kashiwanoha, Kashiwa, 277-8581, Japan*
3. *Collaborative Innovation Center of Advanced Microstructures, 210093, Nanjing, Jiangsu, China*

Recently, both theoretical and experimental results indicate the magnetic rare earth ions located in the geometrically frustrated lattices (e.g., triangular lattice) may form quantum spin liquid states. Rare earth ions in configurations with an odd number of 4f electrons support Kramer doublets which can be treated as an effective spin $J_{eff} = 1/2$. As a quantum spin liquid (QSL) candidate $YbMgGaO_4$, has attracted great attention over the decades. However, the different interpretation of the observed spin-excitation continuum includes a spin glass state of magnetic and nonmagnetic Mg/Ga site disorder due to intrinsic sample issues, respectively, rather than the fractionalized quasiparticles of a QSL.

Compared with $YbMgGaO_4$, the two-dimensional (2D) triangular-lattice rare-earth-based materials NaRESe2 (RE: Rare Earth) with effective spin-1/2 local moments have a hexagonal structure of the space group R-3m and avoid the issue of Mg/Ga site disorders. As a representative member of the ABC-stacking family with the possibility of chirality, $NaYbSe_2$ has received increasing interest of both experimentalists and theorists. Until now all the measurements in this $NaRESe_2$ system focused on the RE=Yb^{3+}. The fruitful results prompted us to undertake an investigation of the physical properties in $NaErSe_2$, a representative material for the research of QSLs and its promising applications. NaErSe2 shows no magnetic order down to 0.36 K, Fig. 2(a), and single-crystal magnetization shows an easy-plane magnetic anisotropy with low-field magnetization [8]. For rare earths, an easy-plane anisotropy often indicates an effective $|Jz = \pm 1/2>$ ground state which allows for significant quantum effects. Meanwhile, the momentum of Er^{3+} is around $9\mu_B$ This makes $NaErSe_2$ candidates for possibly the spin-liquid state and signal is good for triple-axis measurement.

Figure 1 shows the triple-axis inelastic neutron scattering (INS) at 80 mK using the High E-Resolution Triple-Axis Spectrometer (HER) at Japan Atomic Energy Agency (JRR-3) Reactor in Japan. The sample environment is Dilution-refrigerator with magnet. Based on our preliminary results, a continue excitation along Γ-K-M path at 0T, Fig. 1(a), suggests the possible QSL ground state. Interestingly, an obvious Q-dependent excitation behavior at 1T, Fig. 1(b), which may be a field-induced spin-wave excitation. However, we also suspect that the Q-dependent excitation may be attributed to the field-induced splitting of the crystal electron field (CEF) energy level of the ground state. At about 1.2meV, the first excitation state of CEF can be seen, Fig. 1(c). Under 5T, we can observe a field-induced splitting of the CEF energy level. Not only the magnetic field might suppress the quantum effect and induce the magnetic ordering, but also the complicated interplays of CEF, frustration, and exchange interaction are suggested.

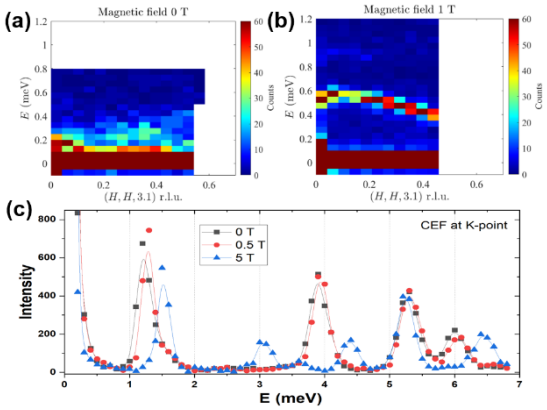

Figure 1: (a) and (b) The inelastic neutron scattering under 0T and 1T at 80 mK using the HER at JRR-3, Japan. (c) CEF at 80mK with the different magnetic fields.