Experimental report

03/08/2018

Proposal:	**4-05-680**	**Council:**	4/2017
Title:	Unveiling the nature of the quantum-spin-liquid behaviors in YbZnGaO4		
Research area:	Physics		

This proposal is a new proposal

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Samples: YbZnGaO4

Instrument	Requested days	Allocated days	From	To
THALES	7	7	28/05/2018	04/06/2018

Abstract:

Quantum spin liquids (QSLs), as a novel quantum state of matter in which strong quantum fluctuation suppresses the conventional magnetic order even down to zero temperature, have drawn much attention owing to their exotic properties and potential applications. Our preliminary results have identified YbZnGaO4 as a new QSL, but the nature of the QSL behavior is not clear yet. Now we propose to carry out INS experiments under a magnetic field high enough to force all the spins to align parallel to the field. The resulting excitations will be spin waves, from which we can extract the exchange interactions for the QSL ground state. The high flux, fine resolutions, and the FlatCone option of ThALES are crucial for the success of this experiment. Totally, we would like to ask for 7 days on ThALES.

Experimental Report of Proposal 4-05-680

Unveiling the nature of the quantum-spin-liquid behaviors in $YbZnGaO_4$

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Quantum spin liquid (QSL) is a novel quantum state of matter in which strong quantum fluctuation restrains the conventional magnetic order even down to zero temperature [1], which has attracted a lot of attention due to the important part in theory revealing unconventional superconductors and potential applications in quantum computing [2], and so on. However, it is hard to realize QSL states, because the presence of small but finite three-dimensional magnetic interactions usually cause some ordered states. Thus the search for QSL material is a long-sought goal experimentally in recent years. Recently the accumulating evidences on $YbMgGaO_4$ suggest the realization of QSL ground state [3-5]. Our results of inelastic neutron scattering measurement on its sister compound $YbZnGaO_4$ also show continuous spectra [6], indicating analogous physics existing compared with $YbMgGaO_4$. To further extract the magnetic exchange interactions of ground state of $YbZnGaO_4$, we plan to carry out inelastic neutron scattering experiments under an external field that is high enough to force all the spins induced to fully-polarized ferromagnetic state.

We have performed the experiment on $YbZnGaO_4$ on ThALES from 28th May to 4th June, 2018. In this experiment, we measured the spin excitations in (H K 0) plane of $YnZnGaO_4$ at 60 mK under 10-T filed with 2.5-g co-aligned single crystals. Here we will show some initial results measured on ThALES.

First we checked the measurements under zero field for the purpose of comparation with that under fields. The continuous excitation spectra along high-symmetry directions and broad diffuse intensity across the Brillouin zone boundary [as shown in Fig. 1 (a) and (b)] are in agreement well with our previous results [6], confirming the QSL behaviors in terms of inelastic neutron scattering. The dispersive pattern around Γ points varies when applying a field of 2.5 Tesla. It has a clear upper and lower edges of 0.7 meV and 0.4 meV, respectively, compared with the missing excitation under zero field. We understand this behavior as a result of partially-destroyed QSL state.

In Fig. 2 (a) we figured out the spin-wave excitations along high-symmetry directions, which is what we expect. If doing a constant-energy cut at E = 2.4 meV, the contour map is shown in Fig. 2 (b). The excitation intensity is centered around Γ points, and there is no spectral weight at Brillouin zone boundary, which is quite distinct from the diffuse scattering along Brillouin zone boundary under zero filed. This phenomenon is more striking by performing the energy scan at high-symmetry positions as shown in Fig. 2(c). Γ point has higher energy excitation compared with M and K points. The 10-T field is high enough to force all the spins to align parallel to the filed, and quantum fluctuations are suppressed, inducing spin-wave excitations in the end.

In conclusion, the measurements under zero, weak, and high magnetic fields have finished, and the spin-wave excitations have been probed when the filed up to 10 Tesla that induces the system into a fully-polarized state, which satisfy our expectation. Next, we will construct theoretical model using linear spin-wave calculations from the results of experimental measurements and obtain magnetic interactions of $YbZnGaO_4$ ground state quantitatively.

References:

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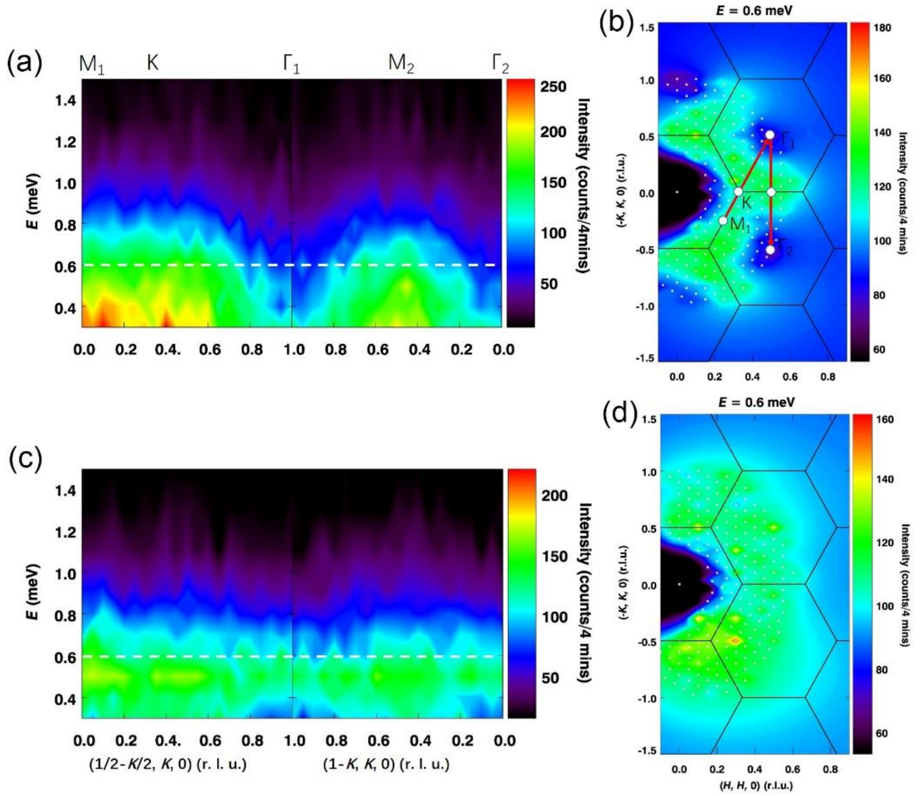

Fig. 1. (a) and (c) are dispersions along two high-symmetry directions illustrated in (b) measured under zero and 2.5-T fields, respectively. (b) and (d) are constant-energy contour plots of the magnetic excitations at E = 0.6 meV, respectively.

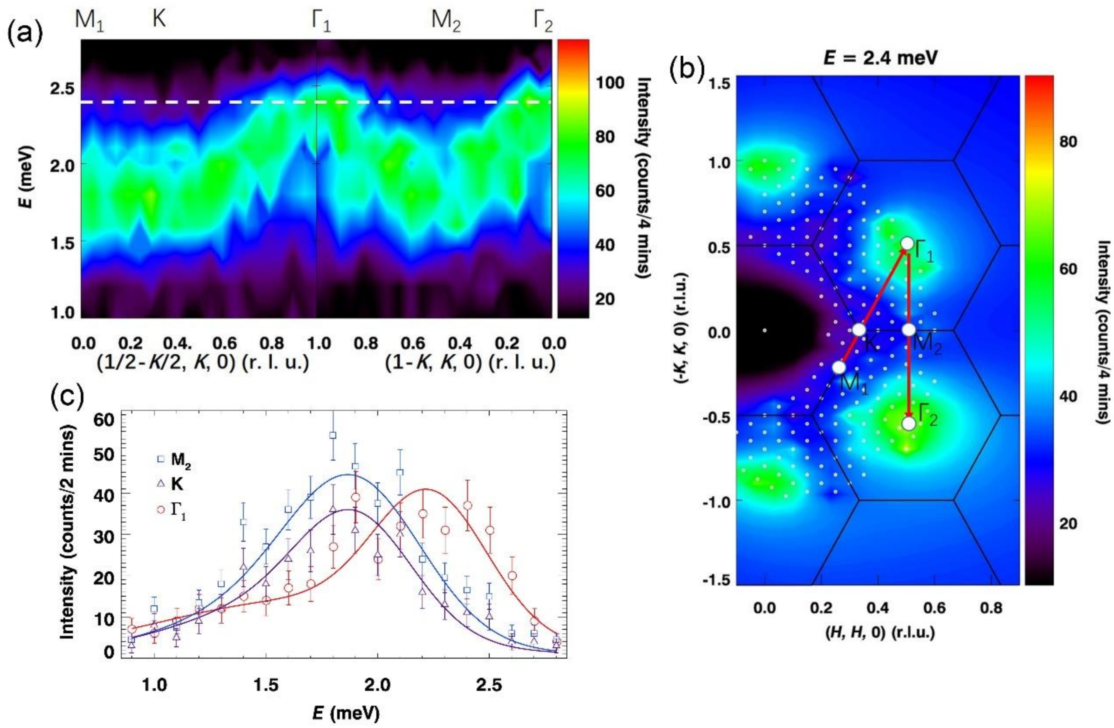

Fig. 2. (a) Dispersion along two high-symmetry directions illustrated in (b) measured under 10-T field. (b) Contour map of the magnetic excitations at E = 2.4 meV. (c) Energy scans of high-symmetry positions in reciprocal space.