Experimental report

28/01/2024

Proposal: **4-01-1807** **Council:** 4/2023

Title: Neutron Scattering Study of Topological Magnon Dispersion in CoTiO3

Research area: Physics

This proposal is a new proposal

Main proposer: **Yaofeng XIE**

Experimental team: Yaofeng XIE
Philippe BOURGES

Local contacts: Frederic BOURDAROT

Samples: CoTiO3

Instrument	Requested days	Allocated days	From	To
IN22	4	4	24/11/2023	28/11/2023
ORIENTEXPRESS	1	1	27/11/2023	28/11/2023

Abstract:

In common antiferromagnetic materials, magnons at the Brillouin zone boundary usually decay much faster than those at the zone center due to a high density of states. However, in a recent Raman scattering study of CoTiO3, the extremely sharp linewidth of magnon at M point suggests a long magnon life at the zone boundary, exhibiting a peculiar momentum dependence of magnon life. Here, we propose to first confirm the feasibility of Neutron Resonance Spin Echo technique (NRSE) on our CoTiO3 sample by a regular triple-axis experiment at IN22 and then determine the intrinsic energy linewidth of the spin waves using NRSE as a function of momentum transfer approaching the zone boundary, which cannot be done by Raman scattering. Such an experiment will shed considerable new light to our understanding of magnon-magnon interaction and decay of magnons as a function of wave vector in quantum materials, particularly for possible topological quantum magnets.

Proposal Number: 4-01-1807

Title: Neutron Scattering Study of Topological Magnon Dispersion in CoTiO3

Experimental team: Yaofeng Xie, Philippe Bourges, Frederic Bourdarot, Yixi Su

Report:

$CoTiO_3$ is a hexagonal A-type antiferromagnet in which a magnon Dirac cone is observed in the K point [1,2]. The spin-orbit couplings generate dispersive spin-orbit excitons, making it an ideal candidate for studying magnon topology and spin-orbit coupling [2]. Recent Raman scattering experiments observed a strong two-magnon mode composed of two M-point magnons. Remarkably, the linewidth of such two magnon mode is extremely sharp, suggesting a long magnon lifetime at the M point. Further calculations at T=0 show that magnon lifetime in this compound exhibit a peculiar momentum dependence, where the magnon decay rate reaches its maximum at the zone center but drastically reduces at the zone boundary. This observation is contrary to those observed in common AFM materials, where a high-density states leads to faster magnon decay at the zone boundary than those at the zone center. The vanishing magnon decay at the zone boundary in $CoTiO_3$ may indicate some conservation rule taking effect, which can have relationship to magnon topology. There, we decided to use the neutron resonance spin echo technique (NRSE) to study the intrinsic energy linewidth of the spin waves as a function of momentum transfer approaching the zone boundary, which cannot be done by Raman scattering.

Before applying NRSE technique, we have to know precisely the local dispersion of the magnon within resolution the triple axis spectrometer IN22, which is the object of this experiment. This experiment was performed on IN22 from 24/11/2023 to 28/11/2023. The sample was mounted in the [H, -2H, 0] × [H, 0, 2H] scattering plane. The Neel temperature of $CoTiO_3$ is 38 K, so we decrease temperature to 4 K and measured several magnon dispersion at this temperature. For [H, -2H, 0] direction, we measured constant Q scans from H = 0.3 to H = 1.15. Fig. 1 shows the overall dispersion along [H, -2H, 0] direction. Magnon dispersion along the other direction was also carefully characterized (Fig. 2).

In conclusion, the local dispersions of the magnon within the ellipsoid resolution of the TAS spectrometer IN22 have been precisely mapped out, confirming the feasibility of the NRSE on our $CoTiO_3$ sample. We will submit a follow-up proposal, to use NRSE technique to determine the intrinsic linewidth of magnon of $CoTiO_3$. Such an experiment will shed considerable new light to our understanding of magnon-magnon interaction and decay of magnon as a function of wave vector in quantum materials, particularly for possible topological quantum magnets.

Reference:

[1] B. Yuan et al. Phys. Rev. X 10, 011062 (2020)

[2] M. Elliot et al. Nat. Comm. 12, 3936 (2021)

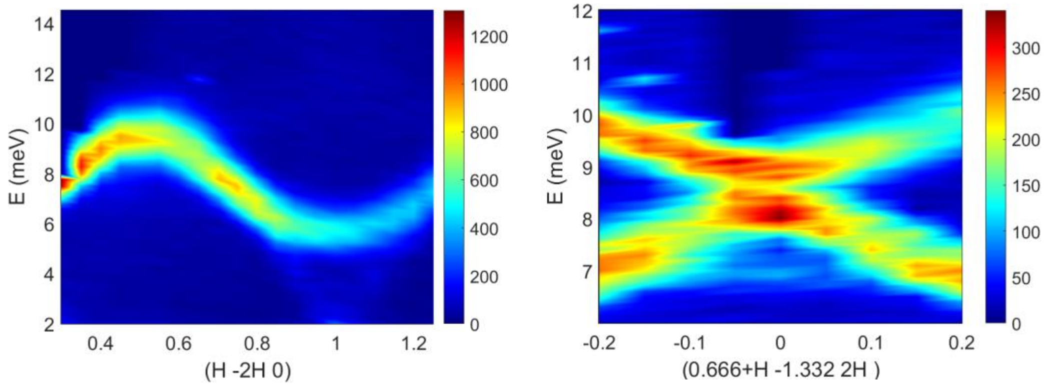

Fig. 1 and Fig. 2, $CoTiO_3$ magnon dispersions measured at IN22.