超伝導・機能材料研究コア セミナー

Highlights from the cold-neutron triple-axis spectrometer SIKA and Magnetic structures of 2D triangular Heisenberg antiferromagnets

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In this presentation, I will introduce neutron scattering techniques and will show the Taiwanese built cold-neutron triple-axis spectrometer SIKA at Australian Center of Neutron Scatetring (ACNS) which has been operated by NSRRC, Taiwan. We are now running the user program since 2015 with over 30 papers published since then. The cold-neutron triple-axis spectrometer SIKA excels at measuring well defined regions in S(Q, ω) space with very low background allowing for parametric studies (eg. varying temperature or magnetic field) to be conducted efficiently. Also, triple axis spectrometers have the advantage of accommodating a wide variety of sample environments and operating with polarized neutrons for both inelastic and elastic scattering experiments. Triple axis spectrometers have been one of most versatile neutron scattering instruments for many areas of neutron science. I will present some of our recent scientific highlights and development shortly in the beginning of the presentation.

After the introduction, I will introduce my current scientific projects. This time, I will mainly talk about magnetic structures of 2D triangular Heisenberg antiferromagnets. A two-dimensional triangular lattice Heisenberg antiferromagnet (2D-THA) is one of the simplest examples of geometrically frustrated antiferromagnets. A novel spin state originated from low dimensionality and competing for magnetic interaction is expected. The materials of interest in this study are (Lu, Y)MnO_3 [3] and (Lu, Sc)FeO_3 [4]. Both have $P6_3cm$ symmetry and 120 degrees antiferromagnetic structures but the exchange interactions in nearest neighbors are $J \sim 2.5$ meV with $S = 2$ (Mn^{3+}) and $J \sim 4.0$ meV with $S = 5/2$ (Fe^{3+}).

We have made a systematic investigation of polycrystalline and single crystals by using neutron diffraction and inelastic scattering experiments. We found that there are four magnetic structures under the $P6_3cm$ symmetry ($P6_3cm$ (Γ_1), $P6_3c'm'$ (Γ_2), $P6'_3cm'$ (Γ_3), and $P6'_3c'm$ (Γ_4)) cannot be distinguished from powder diffraction measurement. In addition, we obtained the spin-wave dispersions at the ordered phase. By using the same spin Hamiltonian below, we have determined the exchange parameters.

$$H = \sum_{\langle i,j \rangle} J_{ij}\vec{S}_i \cdot \vec{S}_j - D_1 \sum_i (S_i^z)^2 - D_2 \sum_i (\vec{S}_i \cdot \vec{n}_i)^2$$

Here, J_1 and J_2 are exchange parameters between Mn or Fe atoms in-plane, J_{1z} and J_{2z} are interplane. The D_1 and D_2 are in-plane anisotropy and out of plane anisotropy. We found interplane interactions are not only delicate parameters but also could be the key of determine the magnetic structures without ambiguity. Unfortunately, neither powder neutron diffraction nor neutron inelastic scattering experiment can conclude. The polarized neutron scattering experiment has been performed in early 2022 to resolve this problem at last.

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