Development of sample cell with permanent magnets for polarized neutron scattering on antiferromagnetic orders with weak ferromagnetism

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Polarized neutron scattering is a very powerful tool to investigate non-collinear and/or non-coplanar magnetic orders, which have recently attracted increasing attention because they induce various cross-correlated phenomena. By measuring spin-flip (SF) and non-spin-flip (NSF) scattering intensities from magnetic Bragg reflections, we can determine the directions of the magnetic moments involved in the magnetic modulation characterized by the *q*-vector corresponding to the reflection. In the fiscal year of 2021, there are a lot of user experiments aiming to investigate the non-collinear magnetic structures at 5G-PONTA. Some of them exhibit non-collinear antiferromagnetic order with weak ferromagnetism. When the sample is cooled in zero magnetic field, the system exhibits a multi-domain state, in which the weak ferromagnetic moments are randomly oriented. This inhomogeneous distribution of the magnetic field in the sample easily depolarizes the neutron spins, and therefore the magnetic structure analysis using polarized neutrons does not work in this situation. Although we can apply a small magnetic field of 5 mT using a Helmholtz coil, which is normaly used to control the directions of the neutron spins at the sample position, this magnetic field is too weak to align the weak ferromagnetic moments in most of the samples.

We thus developed a sample cell with parmanent magnets as shown in Fig. 1. A pair of neodynium magnets with the diameter of 25 mm, which are commercially available standard magnets, are attached just above and below the sample position. A single-crystal sample is attached on an Al plate by standard glue, such as GE vanish, and the Al plate is mounted in the center of the cell. The magnetic field at the sample position is approximately 80 mT at room temperature.

We have perfoemd polarized neutron scattering experiments on antiferromagnetic orders in $CoTa_3S_6$ and $CoNb_3S_6$. The beam polarization measured by nuclear reflections of the samples were typically 80-86%. This shows that that the weak ferromangetic domains are successfully aligned by the magnetic field applied by the permanent magnets, and that the neutron beam was not depolarized. The longitudinal polarization analysis of (weak) ferromagnetic samples can be done by using a vertical field magnet. But this sample cell can be an alternative, which is more easy to handle.

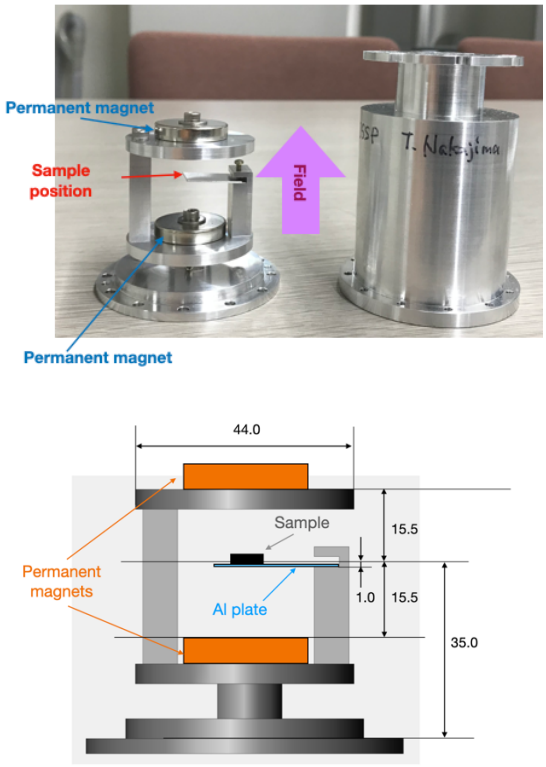

Fig. 1. Photo and schematic illustration of the sample cell with permanent magnets. The 80 mT of magnetic field is applied along the vertical direction (perpendicular to the horizontal scattering plane).