3D polarization analysis using resonance neutron spin interferometry

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This research was performed using monochromatized cold neutron beam line MINE-2. The neutron beam of MINE-2 is well-collimated with the divergence of 1/1000 rad, and monochromatized with 0.88 nm and its wavelength resolution of 3.5%. In addition, polarizing mirrors and suitable coils and current sources are equipped to conduct spin polarization experiments and spin interference experiments.

In the ordinary polarizing experiments, polarization analysis of the sample is performed by getting 3x3 matrix representing the spin rotation in the sample magnetic field. However, provided *z*-axis as quantum axis, the spin directing *x* and *y* axis, representing as |*x*> and |*y*>, respectively can be expressed as superposition of the spin components parallel and anti-parallel to the quantum axis, representing as |z+> and |z->, respectively in the followings. This relation is expressed as follows,

$$|x\rangle = |z+\rangle + |z-\rangle, \tag{1}$$

$$|y\rangle = |z+\rangle + e^{i\pi/2}\,|z-\rangle. \tag{2}$$

The difference between |*x*> and |*y*> is the phase between |*z*+> and |*z*->. In this interpretation, direction of neutron spin is determined by the magnitude and the phase of the coefficient of |*z*-> relative to |*z*+>.

The basic idea of this research is that rotation of the spin due to the magnetic field of the sample can be represented by the magnitude and the phase of the coefficient of |*z*->, instead of measuring 3x3 matrix.

We conducted some experiments to see whether such analysis is possible or not. The experimental arrangement is shown in Figure 1. Cold neutron beam is incident to the polarizing mirror and polarized component is reflected. Then it goes into π/2-flipper to make superposing state of |*z*+> and |*z*->. From the exit of polarizer to the entrance of the analyzer, static vertical guide field is applied not to depolarize neutron spin. The sample is a solenoid with constant current to create horizontal static magnetic field, which oblique magnetic field along with vertical guide magnetic field.

Since MINE-2 has very fine beam, the visibility of interference without the sample is over 0.94.

In Figure 2, examples of the experimental results are shown. Horizontal and vertical axis are the sample current and neutron counts/20s, respectively. The data are being analyzed.

In addition, preliminary experiments for response of oscillating magnetic fields to static neutron beam are also measured.

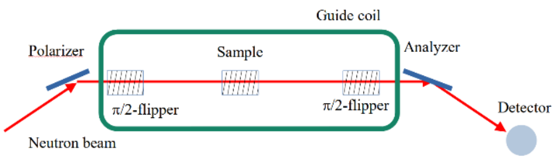

Figure 1 Experimental arrangement of spin interferometry

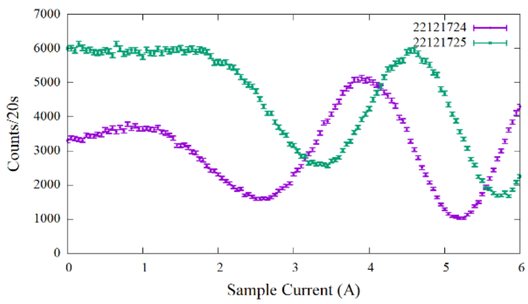

Figure 2. Examples of spin interferometry.