Development of A New Spin-Phase Contrast Imaging of Neutron

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Spin-phase contrast imaging is a method of taking 2D image of the phase difference between spin-eigenfunctions of neutron. Since the phase difference is proportional to the magnetic integral along the neutron trajectory, the image shows the magnetic field distribution over the beam cross section.

The phase difference between the spin-eigenfunctions is measured using neutron spin interferometer (NSI), installed at C3-1-2-2 port of JRR-3M reactor in JAEA. In NSI, neutrons monochromated with 8.8Å($\Delta\lambda/\lambda$ = 2.7%) is polarized and is changed into superposition state of spin-parallel and antiparallel eigenstate to the guide magnetic field by $\pi/2$-flipper. In the middle of the set-up, the spin state of neutron is reversed by π-flipper, in order to realize spin echo of neutron, with which additional phase difference caused by outer magnetic field can be canceled. Then after going through the sample, neutron comes to the second $\pi/2$-flipper and spin-analyzer, where the measured neutron counts are proportional to the cosine of phase difference. Available beam area is 2mm(w)$\times$20mm(h).

In the experiments, neutron counts are measured via additional phase ϕ, the counts are fitted to $A(1+\cos(\phi_0+\phi))$ and ϕ_0 is the desired phase difference. In the present study, the additional phase is introduced as phase difference of rf-current to $\pi/2$ and π-flipper.

As neutron detector, we adopt 2D Photo Multiplier with Li-glass scintillator and neutron imaging plate (IP). The former has real-time read out system but low spatial resolution, where the latter has very high resolution but requires off-line read out.

With the former detector, we made preliminary experiments and confirmed the relation between magnetic field and phase difference in the case of magnetic coils (via electric current) and magnetic thin layer (via incident glancing angle).

With the IP, neutron imagines for different additional phase is recorded in a single IP. An example is shown in Fig. 1. The left picture is the sample, which is a 6Q polarizing supermirror with total thickness of magnetic layers is about 6μm. The sample was kept in non magnetic atmosphere for months. Hence the sample was demagnetized gradually. Left picture in Fig.1 is a photograph of the sample. Middle picture is normal transmission image, where no clear image is shown since almost all neutrons are transmitted. Right picture is the phase image, where inhomogeneous distribution of magnetic field is shown.

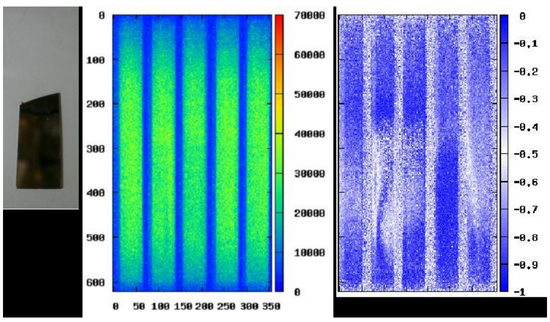

Fig. 1. The results of the spin-phase contrast imaging of neutron using imaging plate.