Visualization of Electric Current by Neutron Spin Phase Contrast Imaging

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Neutron spin phase contrast (NSPC) imaging is a method to visualize the magnetic field integral along the trajectory of neutron. The principle of NSPC is to measure additional phase difference between spin eigenstates of Larmor precessing neutron, by means of neutron spin interferometry. In NSPC imaging, neutron intensity changes sinusoidally,via the phase difference of incident neutron. When magnetic field exist on the way of neutron, the sinusoidal curve is shifted, and the shift is proportional to the magnetic field integral. Moreover, the contrast (visibility) of the sinusoidal curve may change depending on the homogeneity and direction of the magnetic field. In the present study, we apply NSPC method to measure magnetic field induced by electric current, to develop NSPC imaging to visualize electric current distribution.

As a sample, an Al-cylinder with 10mm-diameter and 20mm-length sandwiched by Cu plate is adopted. The electric current flows along with the cylinder. Such current produces the magnetic field proportional and inversely proportional to the distance from the center of the cylinder, inside and outside of the Al-cylinder, respectively. Neutron experiments were performed at C3-1-2-2(MINE-2) beam port of JRR-3M in JAEA. Wavelength of the neutron beam is 0.88nm ($\lambda/\delta\lambda$ =2.7%), available beam size is 10mm in width and 30mm in height. Incident neutron is polarized vertically with 5Q-supermirror polarizer fabricated with Ion Beam Sputtering system in KUR. Then the spin of the neutron is half flipped with resonance neutron flipper. In the middle of the set-up, PI-flipper is installed in order to cancel outer magnetic field and to introduce phase difference ϕ between two spin states of neutron. The sample is located after the PI-flipper and then PI/2-flipper and spin analyzer is set for analyzing the phase of neutron spin wave. Neutron spin analyzer is a V-shape polarizer with 5Q-polarizing supermirror and the transmitted neutron is measured with 2D-RPMT with Li-glass scintillator. Interference fringe is obtained from the change of neutron intensity via the phase between neutron spin states.

An example of measured results is shown in Fig.1. The electric current through Al-rod is 7.5A. The measurements were performed for other values of ϕ, and the phase induced by the magnetic field caused by the electric current is to be analyzed.

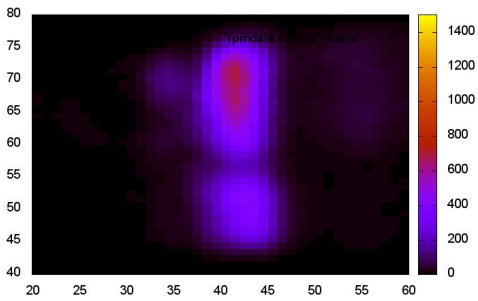

Fig. 1. An example of measured result. Neutron distribution changes as the phase difference between two spin eigenstates of neutron, introduced via resonance spin flippers.