Development of Fourier imaging techniques using low-frequency MIEZE method

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MIEZE (Modulation of Intensity with Zero Effort) is a variation of Neutron Spin-Echo method, which creates the periodic modulation of intensity of neutron beam utilizing the difference of the frequency of the oscillating current between the two resonance spin flippers. In this research, modulated neutron beam is used to obtain the Fourier images of a periodically moving object.

Experimental set-up is shown in Fig.1. MIEZE setup is composed of a spin polarizer, an analyzer, and two spin flippers (RSF1, RSF2). Neutrons are polarized by Polarizer and flipped twice by resonance spin flippers (RSF1 and 2). The frequency of the oscillating current for RSF1 and 2 is different, hence the amplitude of the spin-up component of the neutron wavefunction is modulated. The oscillatory modulation of the beam intensity is realized by the amplitude modulation after the analyzer. When the transmission of the modulated neutron beam is measured for certain time through a periodically moving object, then Fourier coefficient of the object for the MIEZE frequency is obtained. The modulated beam intensity is expressed as $A(1+V\cos(\omega t+\phi))$, and the movement of the sample is represented by $f(t)$, observed intensity I_t is given by

$$I_t = \int_0^{t_p} f(t) \times A(1 + V\cos(\omega t + \phi))$$

where t_p is the period of the sample movement.

In the present study, cooling fan is adopted as the sample. A 1mm-thick Cd plate is stuck to the motor of the fan, to intercept the neutron beam. An optical pick-up is attached to the sample and generates the start pulse to synchronize the movement of the sample and the oscillation of the beam intensity. Since neutron beam is almost completely stopped by the Cd, aperture function of the sample is represented like Fig.2, for example, where aperture is unity or zero when the Cd plate is out of or on the beam, respectively.

In the experiment, averaged neutron intensity is measured with 3He detector for 50 seconds, varying MIEZE frequency. The intensity dependence of the frequency is shown in Fig.3. In Fig. 3, purple points with error bar represent the neutron counts, and oscillatory change via MIEZE frequency is observed. The green solid line represents the calculated Fourier coefficient using the aperture profile shown in Fig. 2, and obviously, it reproduces well the experiment.

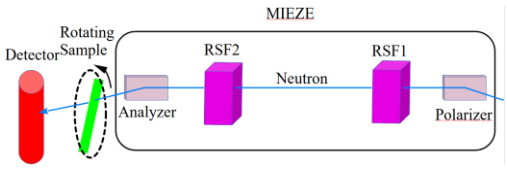

Fig.1 Experimental setup. After the Anlayzer neutron beam intensity is periodically modulated.

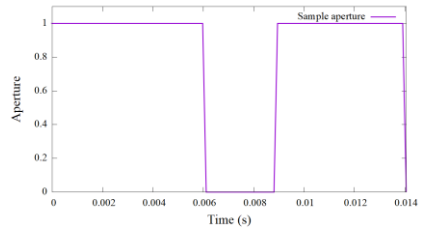

Fig.2 An example of aperture function of the present study.

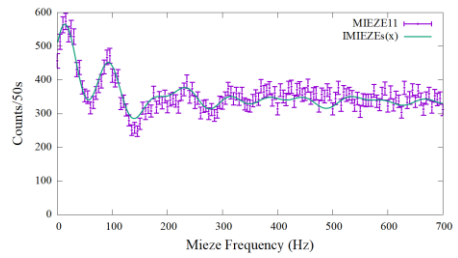

Fig.3 Change of visibility of the spin interference pattern via $\Delta\phi$.