Development of an oscillating magnetic field system in a neutron spin interferometry for the dwell time measurement

R. Fujitani[A], M. Hino[A] and T. Higuchi[A]

[A]Kyoto University

In this experiment, a new method, named spin phase continuous modulation (SPCM), which measures the neutron velocity and its dispersion has been studied [1]. The experimental setup is shown on Fig. 1. The setup consists of a neutron spin interferometer, which measures the neutron spin precession angle induced between RSFs. Inside the interferometer, there are two modulator coils (RF coils) which produce oscillating magnetic fields along the neutron spin quantization axis. They modulate the spin precession. The phase difference of the spin modulation induced by RF coils is proportional to the neutron transversal time between the RSFs. Therefore, when the distance between the RSFs is known, the neutron velocity can be determined.

A SPCM signal can be described by the frequency f, the phase ϕ of the oscillating magnetic fields, the neutron velocity v and the distance between RSFs l.

$$N = \frac{N_0}{2}\left\{1 + J_0\left(\frac{4|\mu_n|}{\hbar v}|b(k)|\cos\left(\frac{\pi f l}{v} + \frac{\phi}{2}\right)\right)\right\}. \quad (1)$$

Here, μ_n is the magnetic moment of the neutron, $|b(k)|$ is a power spectrum of the shape of oscillating fields and N_0 is the maximum neutron counts and N is measured neutron counts. The SPCM signal can be obtained as change of neutron counts N. By changing the phase ϕ, a SPCM signal shows periodic changes. Also, when the distance between RSFs l is changed, the phase of the SPCM signal shifts $2\pi f l/v$. Thus, neutron velocity can be measured. When the neutron velocity has a finite distribution, the SPCM signal is smeared along the phase ϕ, resulting in the decay of the peak in SPCM signal. This effect can be described by the convolution of the SPCM signal with the neutron velocity distribution.

The measured SPCM signal is shown on Fig.2. The horizontal axis shows the phase between RF coils ϕ. The vertical axis shows the value of $J_0(4|\mu_n||b(k)|/\hbar v\cos(\pi f l/v + \phi/2))$. The red line shows the fitting result of Eq. (1). This model does not take into account the neutron velocity dispersion. The blue line shows the fitting result to the model which takes the velocity dispersion into account. From these results, the decay of the peak in the SPCM signal has been observed.

The original objective of this experiment was to apply SPCM to fundamental physics experiments. However, through this study, we found that SPCM is highly sensitive to neutron velocity dispersion, suggesting that it has the potential to be applied to inelastic neutron scattering. In particular, the ability of SPCM to measure the neutron velocity distribution provides a potential for quasi-elastic neutron scattering experiments.

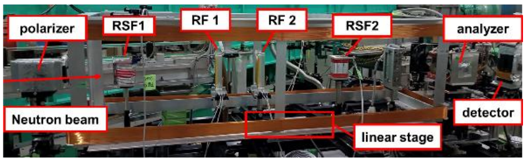

Fig. 1. Experimental setup of SPCM

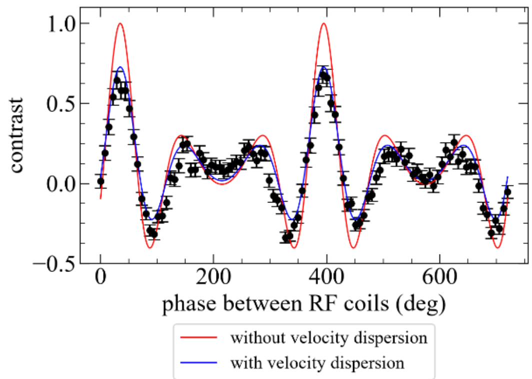

Fig. 2. Obtained SPCM signal when the frequency is 10kHz, the distance is 180mm

[1] R. Fujitani *et al.,* arXiv:2605.28661