Development of resonance spin flipper with iron yoke

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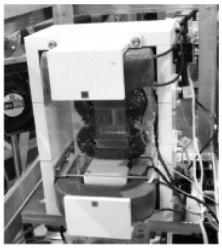
Neutron spin echo (NSE) is one of the techniques with the highest energy resolution for quasi-elastic scattering by measuring rotation of the neutron spin[1]. In neutron resonance spin echo (NRSE), two resonance spin flippers (RSFs) replace a homogeneous static magnetic field for spin precession in the conventional NSE[2]. An RSF, which flips the spin of a neutron by exchanging energy between the neutron and an oscillating magnetic field, gives the difference of wavenumber between up- and down-spin components of the neutron. The relative phase between the two spin components, which is equivalent to spin rotation, is provided by the difference of wavenumber in the area between the RSFs. A RSF consists of a static magnetic field and an oscillating magnetic field. The static field is proportional to the frequency of the the oscillating field. It was quite difficult to provide the strong static field corresponding to the high frequency up to 500kHz by using air-core coils. New type of RSF has been developed by using dipole magnet with iron poles for the static magnetic field (figure 1). It could provide strong magnetic field with less current, however, magnetic flux leak and its surface was not well-defined.

The gap between the two iron poles had the height of 150mm. The dipole magnet had the uniform magnetic field with the center area of 15mm width, 15mm height and 50mm long. The uniformity was less than 10% . About 20mT was measured at the center of the uniform field area with the current of 8A. The magnetic field was quite stable by using the regulated power supply. Temperature of the coil was also stable for the magnetic field which was less than 20mT without any additional cooling system. The return field was enclosed by iron yoke around the magnet well.

Test experiments to observe MIEZE signals with high frequency by using the new RSFs have been performed using the cold neutron beam line MINE1 at JRR-3 reactor at JAEA. The beam had the wavelength of 0.81nm and the bandwidth of about 10 % . Figure 2 shows the MIEZE signal with normalization of the detector efficiency. Neutron counts modulated according to the phase of the oscillating field of the RSFs. The effective frequency of the modulation was 600kHz. The contrast of the signal was 0.58.

This demonstrated the stability and the smoothness of the magnetic fields provided by the dipole magnets. MIEZE spectrometer is under final process to practical use. We are also continuing to develop RSF with much higher frequency for NRSE spectrometer with high resolution. We will utilize the new system including the new RSFs for the development of a neutron spin echo spectrometer at J-PARC[3].

[1] F. Mezei, Z. Phys. 255(1972)146.
[2] R. Gaehler, R. Golub, Z. Phys. B65(1987)43.
[3] Y. Kawabata, et. al., Nucl. Instr. and-Meth. A574(2006)1122.



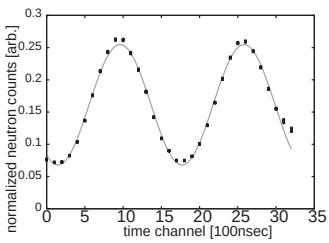


Fig. 1. (Left) RSF with dipole magnet with iron pole.
Fig. 2 (Right) MIEZE signal with 600kHz.