Development of a broad band $\pi/2$ spin flipper with a gradient field RF

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Neutron spin flipper is a device used in polarized neutron experiments to change the spin eigenstate of neutron. A standard setup of neutron spin echo (NSE) spectrometer has one π-flipper and two $\pi/2$-flippers. The Mezei-type flipper has the advantage of being compact (a few to 10 centimeters). Disadvantages of this type of flipper lie in the following points. The compensation coil needs to be finely tuned every time the surrounding magnetic field changes. It basically works for monochromatic wavelength. Therefore, the initial setting for all combinations of precession coil currents and wavelengths can be time-consuming. Also, the wires of the coils are in the path of neutron beam, which could cause background scattering. There is a different type of spin flipper based on the adiabatic fast passage [1], called "gradient field RF" flipper [2]. This flipper does not have the drawbacks mentioned above. Basically, no adjustment is required even if the wavelength or precession coil current is changed. The drawback of gradient-field RF flippers is that they may require some space to install rather than Mezei-flippers. To verify the advantages of using a gradient-field RF flipper as a $\pi/2$ flipper for iNSE, we designed a prototype flipper and made preliminary experiments for the performance test. As a prototype, the static gradient field was made from bar magnets of different lengths and iron plates, and the RF field was made from a solenoid coil with copper wires wound around an acrylic hollow cylinder. The spin flip measurement was done at the iNSE sample position.

Results: Figure 1 shows the wavelength dependence of the neutron intensity measured for reference of the incident beam properties. The shortest wavelength available at iNSE is approximately 4.0Å (NVS speed: 28000 rpm), which corresponds to the maximum neutron velocity of 989 m/s. The flipper must be designed so that the adiabatic condition [1] is sufficient for this velocity. Figure 2 shows the result of flipper test with RF of 50 kHz with a wavelength of 7.3 Å (542 m/s), indicating some reasonable spin flip. We will test it at other wavelengths and in different magnetic field environments to verify its usefulness.

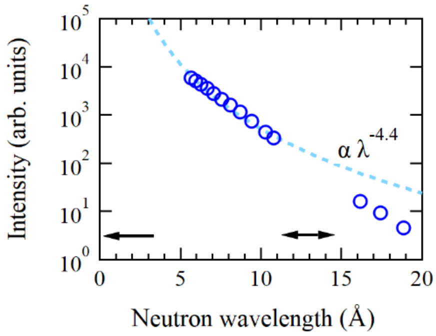

Fig. 1. Wavelength dependence of neutron intensity measured by the main detector of iNSE. The dashed line indicates the best-fit power law of wavelength, λ. The blank region indicated by black arrows are due to vibration resonances or speed limits of NVS.

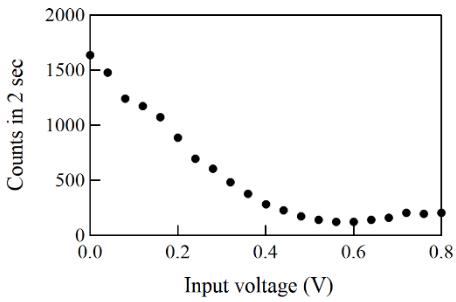

Fig. 2. Dependence of neutron intensity on the amplitude of RF magnetic field of the flipper. The neutron wavelength was 7.3 Å. The RF field amplitude is proportional to the input voltage.

[1] A. Abragam, "Principles of Nuclear Magnetism", Clarendon Press, London (1961).

[2] A.N. Bazhenov, V.M. Lobashev, A.N. Pirozhkov, V.N. Slusar, Nucl. Instrum. Methods A, **332**, 534-536 (1993).