Precise magnetic field measurement of WiSES

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WiSES[1] (Window-frame Spectrometer for Electron Scattering) is an electron spectrometer for the SCRIT (Self-Confining RI Ion Target) experiment.[2,3] The dipole magnet[4] of WISES has a large aperture for the measurement of scattered electrons in a wide scattering angle at once. The gap volume of the magnet is 140 cm (width), 29 cm (height), 170 cm (depth). In elastic electron scattering experiments, a typical momentum resolution of $\delta p/p \sim 10^{-3}$ for 150–300 MeV electron energy is required to separate elastic and inelastic scattering events. The momentum resolution measured by elastic scattering for ^{12}C and ^{208}Pb is found to not reach the design value. To improve further momentum resolution, we will measure the precise 3D magnetic fields of the WiSES magnet with a precision of $\delta B/B \sim 10^{-3}$.

We will use three Hole probes to measure B_x, B_y, and B_z at the same time. The Hall probe has a Hall sensor inside and reacts to the component of the magnetic field with respect to the normal direction of the sensor surface. However, the Hall probe also detects the magnetic field with respect to the tangent of the sensor, namely the Planar Hall effect.[5] $B_{\rm probe}$ detected by the Hall probe is expressed as follows:

$$B_{\rm probe} = B\cos\theta + p_{\rm H}(B\sin\theta)^2\sin 2\phi, \qquad (1)$$

where θ is the angle between the normal direction of the sensor and the magnetic field, and ϕ is the rotation angle of the sensor. The first term in Eq. (1) is the Hall effect. The second term in Eq. (1) corresponds to the Planar Hall effect. To determine the value of the Planar Hall coefficient $p_{\rm H}$ of the second term, we measured the 2ϕ dependence of each probe in a uniform magnetic field.

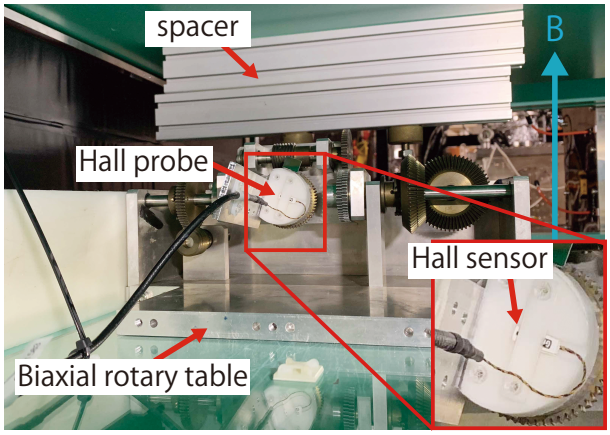

Fig. 1. Setup of Planar Hall effect measurement in WiSES.

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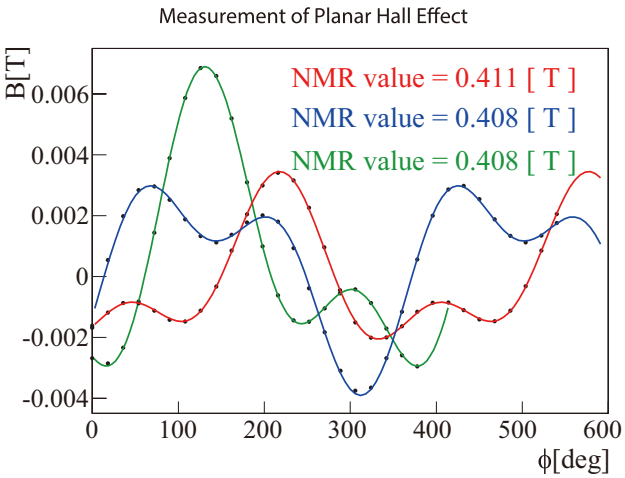

Fig. 2. Result of 2ϕ dependent magnetic field by the Planar Hall effect. Each color corresponds to the fitting for each probe.

The setup is shown in Fig. 1. The probe was mounted on a rotating stage in the homogeneous field region of the WiSES magnet. The absolute value of the field was measured by NMR, which was also located in the homogeneous region. The stage could rotate around two axes corresponding to θ and ϕ of Eq. (1), with resolutions of 0.3 mrad. In this measurement, θ was set to be 90° to suppress the influence of the first term of Eq. (1). The results for the three probes are shown in Fig. 2. By adding some mis-alignment angles of our system as fitting parameters into Eq. (1), our data are well reproduced. In the present fitting, the followings points are included:

(a) the contribution from the first term of Eq. (1) owing to a small deviation from the 90°,
(b) the angle between the probe and the rotary axis of the stage, etc.

Consequently, the $p_{\rm H}$s are evaluated to be 0.008, 0.01, and 0.015. These values are consistent with a previous study ($p_{\rm H} = 0.0148$).[6] NMR values for each probe are shown in Fig. 2. Although, the evaluation of systematic errors are ongoing. We will mount three probes on a system to make a triaxial probe, and create a precise map of the magnetic field of the WiSES magnet at the next stage.

References

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