Experimental Simulation and Model Validation of the Hanle Effect in Solar Atmosphere Using a Laboratory Plasma

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Magnetic structures in the solar atmosphere provide fundamental information for investigating heat and particle transport phenomena. The Zeeman-Hanle effect has been widely used to study the fine magnetic structures through spectropolarimetric measurements. While the accuracy and precision of spectropolarimetric and inversion methods have been improved, validation of these techniques relies on theoretical models or on the solar atmosphere itself in most cases. Our motivation is to verify and validate these techniques experimentally in a simplified laboratory system, where plasma parameters can be controlled and results can be cross-validated with independent diagnostics.

We developed an inductively coupled plasma (ICP) system[1], and installed it in front of the focal plane of the Horizontal Spectrograph of the Domeless Solar Telescope at Hida Observatory of Kyoto University. The spectrograph is equipped with a spectropolarimetric system with high spectral resolution and high polarimetric sensitivity[2], and it is usually operated for solar observations. In the ICP system, anisotropic radiation fields are generated intrinsically at the observation port, and we observed scattering polarization in the helium plasma. By applying weak magnetic fields up to 20 G using external Helmholtz coils, we experimentally measured Zeeman-Hanle signals. The magnetic field was independently measured by a Hall sensor. We compared the experimentally obtained spectropolarimetric signals with theoretical Zeeman-Hanle profiles. In the presentation, we discuss the results of the helium triplet lines at 1083 nm and 587 nm using the ICP system.

[1] T. Kawate et al., Plasma Fusion Res. 18, 1401037 (2023)
[2] K. Ichimoto et al., Tech. Rep. Astron. Obs. Kyoto Univ. 6, 3 (2022)