Contribution ID: **42** Type: **Poster**

Measurement of Spin Polarization in SERF Hybrid Optical Pumping Atomic Magnetometer via the Steady-State Response to the Triaxial Magnetic Field

Thursday 7 August 2025 18:20 (5 minutes)

In SERF atomic magnetometers, the spin polarization of alkali-metal atoms is a critical parameter affecting the signal-to-noise ratio. The signal of the magnetometer is optimal for a particular spin polarization, and higher spatial uniformity of spin polarization enhances the signal. Hybrid optical pumping is a method to improve the spatial uniformity of spin polarization. The signal of the hybrid pumping magnetometer is influenced by multiple parameters, including temperature, alkali-metal density ratio, pump light power and frequency, and probe light power and frequency. Therefore, precise measurement of the spin polarization and its spatial distribution in SERF hybrid pumping magnetometer is essential to optimize its response signal.

This study proposes a novel method for measuring alkali atomic spin polarization based on the steady-state response of a SERF hybrid optical pumping atomic magnetometer to the triaxial magnetic field. First, different DC magnetic fields were applied in the x- and y-axes and y- and z-axes, and the total relaxation rate at a specific position within the vapor cell was obtained using the ratio of the system's steady-state responses under these two conditions. Next, the transfer coefficient between spin polarization along the probe light direction and the steady-state response was calculated, where the optical depth of the probe light was utilized to derive alkali-metal atomic density, compensating for temperature gradient effects. Finally, a DC magnetic field was applied along the sensitive axis of the magnetometer, and the spin polarization was obtained using the steady-state response, transfer coefficient, and total relaxation rate. The advantages of this method include eliminating the need for optical field manipulation or large magnetic fields, reducing errors from residual fields, coil constant calibration, temperature gradients, and by spatially displacing the probe light enables the acquisition of the spatial distribution of spin polarization along the propagation direction of the pump light. Experimental results aligned with simulations, with a maximum deviation below 6%. The expanded uncertainty of measurements ranged from 1.1% to 9.8%. This method provides precise measurement of atomic spin polarization, which is of significant importance for enhancing the sensitivity of SERF hybrid pumping atomic magnetometers and laying the foundation for ultra-weak magnetic field detection.

Authors: WANG, Faming (Beihang University); MA, Danyue (Beihang University); LV, Haoran (Beihang University); XUE, Yangzhi (Beihang University); DOU, Yao (Beihang University); ZHANG, Yaqi (Beihang University); FANG, Xiujie (Beihang University); GAO, Yanan (Beihang University)

Presenter: WANG, Faming (Beihang University)

Session Classification: Poster Session and Buffet