SERF magnetometer using reflected light for detection

Wei Xiao[1], Yulong Wu[1], Yulong Feng[1], Xiang Peng[1], Jingbiao Chen[1], Hong Guo[1]

[1] State Key Laboratory of Advanced Optical Communication Systems and Networks, School of Electronics Engineering and Computer Science, and Center for Quantum Information Technology, Peking University, Beijing 100871, China

The spin-exchange relaxation free (SERF) magnetometer can achieve subfemtotesla sensitivity by suppressing spin exchange relaxation, which makes it a promising highly-sensitive non-cryogenic sensors in magnetoencephalography (MEG) [1]. We have designed a simple and compact experimental scheme of SERF magnetometer to further reduce the distance between the sensor and the scalp to enhance the strength of MEG signal. As shown in the Fig.1(a), A 795 nm DFB laser is performed as both pump and probe, which is on resonance with Rb D1 transition. A 5 mm cubic cell, filled with natural abundance Rb and 600 torr N_2, is heated to 160°C and placed inside a cylindrical magnetic shield. The coils inside the shield generate an RF magnetic field $B_{\rm rf}$ (≈ 100 nT) at 910 Hz to modulate the magnetic signal being monitored so that lock-in detection can be used to suppress low-frequency noise in the light signal.

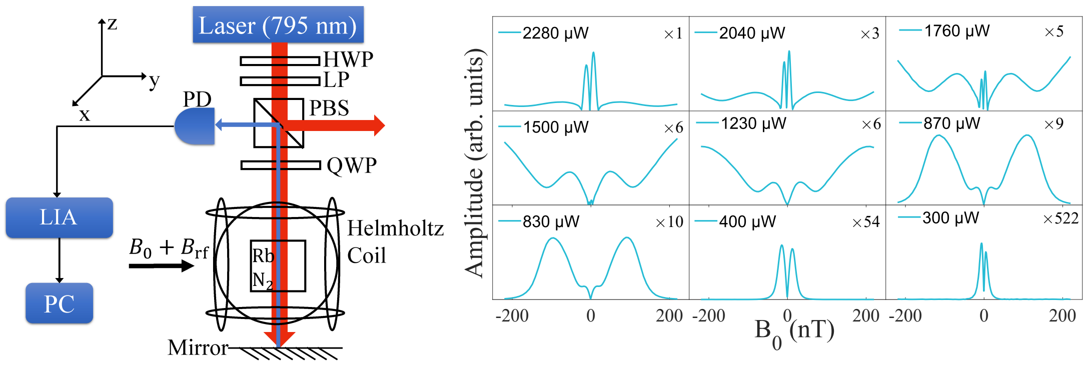

Figure 1. (a) Schematic of the experiment setup. HWP, half-wave plate; LP, linear polarizer; PBS, polarizing beamsplitting; QWP, quarter-wave plate; PD, photodetector; LIA, lock-in amplifier; (b) Optical power dependence of the Hanle effect for Rb. These plots indicate the ordinate-axis multiplicative factor necessary to make them identical in scale to the first plot.

As shown in Fig.1(b), the Hanle absorption profiles for a σ^+ polarized incident light in the presence of the σ^+ polarized reflected light show dependence on light power. When the power is low, the profile is normal [2] with 10 nT narrowest linewidth (FWHW). However, if the light power is increased, there will be two new peaks with narrower linewidth compared with the previous peaks and the profile will become complex. In this way, the two narrower new peaks can probably be used to measure magnetic field with high sensitivity.

[1] Boto E, Holmes N, Leggett J, et al, Moving magnetoencephalography towards real-world applications with a wearable system, Nature **555**, 657 (2018).
[2] Shah V, Knappe S, Schwindt P D D, et al, Subpicotesla atomic magnetometry with a microfabricated vapour cell, Nature Photonics **11**, 649 (2007).