Development of ultrasensitive atomic magnetometer for fundamental physics and biomagnetism

Yucheng Yang[1], Liang Shen[1,2], Rui Zhang[1,3], Wei Xiao[1], Zhiguo Wang[3], Teng Wu[1], Xiang Peng[1], Jingbiao Chen[1], Hong Guo[1†]

[1] State Key Laboratory of Advanced Optical Communication Systems and Networks, Department of Electronics, and Center for Quantum Information Technology, Peking University, Beijing 100871, China
[2] State Key Laboratory of Information Photonics and Optical Communications, Beijing University of Posts and Telecommunications, Beijing 100876, China
[3] College of Liberal Arts and Sciences, and Interdisciplinary Center for Quantum Information, National University of Defense Technology, Changsha 410073, China
[†]Corresponding author: hongguo@pku.edu.cn

Investigations of atomic magnetometer are paid much attention and got rapid progress for the decades, while atomic magnetometers with improved sensitivities are achieved and the effort for its applications on fundamental scientific research [1], medical research [2], etc. are reported continuously. In this talk, we at first introduce a novel method to stabilize the magnetic field. By connecting the internal coils of two magnetic shields in series, the magnetic fields in the two shields are generated with the same current source. The high-sensitivity reference magnetometer in one magnetic shield is used to stabilize the current which generates a stabilized magnetic field in the other magnetic shield. This method can avoid the influence of the magnetic gradient when the reference magnetometer is in the same shield with the working magnetometer. A bias field with a high stability is essential for the applications of atomic magnetometer in the tests of fundamental symmetries and searches for new physics. We then propose and test a new kind of comagnetometry based on Zeeman transitions of the dual hyperfine levels in the ground state ^{87}Rb atoms. Our comagnetometer is experimentally shown to have nearly negligible sensitivity to dominant systematics for applications of comagnetometer in the tests of fundamental physics, and holds the potential to reach 10^{-18} eV level for measuring the hypothetical spin-dependent gravitational energy of the proton. Also, we develop a miniaturized optical fiber-coupled spin-exchange relaxation-free magnetometer [3, 4], which is applied for measuring MEG signals. The sensitivity of the magnetometer has currently reached 20 fT/$\sqrt{\text{Hz}}$ @ 10 Hz and the size of the sensor is 38 mm × 38 mm × 60 mm. The MEG signal in the real world is being collected and processed by cooperating with the hospital in Beijing.

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