Contribution ID: **47**

Type: **Poster**

Single-beam Triaxial Spin-exchange Relaxation-free Magnetometer

Thursday 7 August 2025 17:40 (5 minutes)

Unlike electrical signals, magnetic signals are not affected by the biological tissues because of the nearly homogeneous permeability. Therefore, magnetoencephalography (MEG) is more suitable for detecting biological phenomenon. In the past several decades, superconducting quantum interference device (SQUID) magnetometers are most commonly used for MEG. However, the SQUID magnetometers would not work unless the superconducting circuits are housed in the liquid-helium-cooled dewar. The cryogenic cooling brings some significant problems [1]. Optically pumped atomic magnetometers in the spin-exchange relaxation-free (SERF) regime have attracted significant attention [2]. Compared with the SQUID magnetometers, SERF magnetometers have the sensitivity comparable to that of the SQUID magnetometers but do not need the cryogenic condition. Substantial research efforts have been devoted to improving the performance of SERF magnetometers. Recently, one of the hot research topics is how to realize the three-axis magnetic field measurement. It is helpful to obtain the complete vector information of the magnetic field.

Here, we propose and experimentally demonstrate two novel schemes to achieve measurement of three-axis vector magnetic fields. One approach employs a specially designed triangular prism-shaped vapor cell [3]. By reflecting the light beam in the cell chamber under high pressure, the atoms before and after reflection are polarized along two different directions. It is as though two dual-axis parametric resonance magnetometers are combined in the same vapor cell. A sensitivity of 40 fT/Hz1/2 in x-axis, 20 fT/Hz1/2 in y-axis, and 30 fT/Hz1/2 in z-axis is achieved. Another scheme is by utilizing a dual-resonance effect, which is discovered for the first time in the SERF regime. This is an easy-to-implement engineering solution. On the basis of a dual-axis parametric resonance magnetometer, as long as the rotating field frequency is reduced from kilohertz to hundreds of hertz, then Mz resonance is excited synchronously, and hence the dual-axis magnetometer can be upgraded with three-axis measurement capabilities. Eventually, we can attain magnetic field sensitivities of about 40 fT/Hz1/2 in x- and y-axes and about 50 fT/Hz1/2 in the z-axis [4].

References

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Session Classification: Poster Session and Buffet