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SERF Comagnetometer Based on Self-differential Mode

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Spin-exchange relaxation-free (SERF) comagnetometer is significant in exploring fundamental physics and high-precision inertial sensing. However, traditional continuous measurement based on steady atomic spin polarization limits the suppression of long-term drifts, which is pivotal for inertial navigation and the search for new physics beyond standard model.We propose a SERF comagnetometer based on self-differential measurement mode using reverse-modulated atomic spin polarization for signal enhancement and noise suppression, as is shown in Fig.1(a). We analyze the dynamic evolutions of alkali electron spin and noble-gas nuclear spin under the pulsed left- and right-circularly polarized pumping scheme. To ensure that the comagnetometer operates in self-compensation regime[Phys. Rev. Lett. 130 . 063201(2023)], we reverse the electron spin while keeping the nuclear spin polarization stable by optimizing the modulation period and duty cycle. Through self-differential, the response of the comagnetometer is improved by 2.95 dB and the low-frequency common-mode at 0.1˜2 Hz is suppressed by about 6.53 dB. As is shown in Fig.1(b), the sensitivity is improved by 2.7 times to $3.1 \times 10^{-6}\,^{\circ}/\mathrm{s}/\sqrt{\mathrm{Hz}}$ @1 Hz compared with the traditional continuous measurement mode.

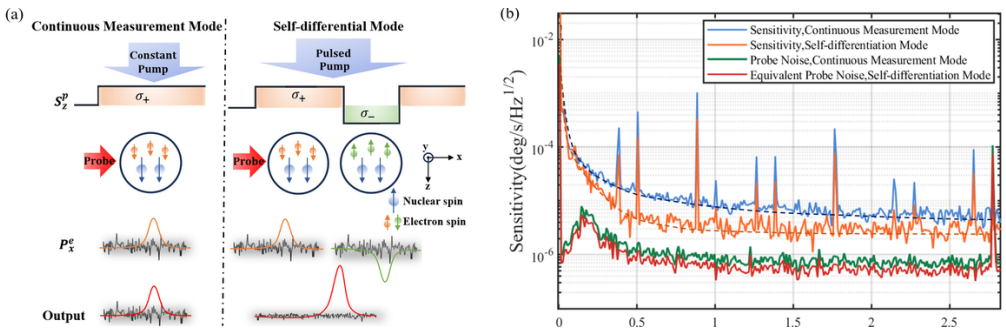

Figure 1: (a) Principle (b) Sensitivity and probe noise of SERF comagnetometer based on continuous measurement mode and self-differential mode.

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