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A Differential Detection Method for Chip-Scale Spin-Exchange Relaxation Free Atomic Magnetometer

Authors : Yi Zhang, Yuan Tian, Jiehua Chen, Sihong Gu

Abstract : Chip-scale spin-exchange relaxation free (SERF) atomic magnetometer makes use of millimeter-scale vapor cells micro-fabricated by Micro-electromechanical Systems (MEMS) technique and SERF mechanism, resulting in the characteristics of high spatial resolution and high sensitivity. It is useful for biomagnetic imaging including magnetoencephalography and magnetocardiography. In a prevailing scheme, circularly polarized on-resonance laser beam is adapted for both pumping and probing the atomic polarization. And the magnetic-field-sensitive signal is extracted by transmission laser intensity enhancement as a result of atomic polarization increase on zero field level crossing resonance. The scheme is very suitable for integration, however, the laser amplitude modulation (AM) noise and laser frequency modulation to amplitude modulation (FM-AM) noise is superimposed on the photon shot noise reducing the signal to noise ratio (SNR). To suppress AM and FM-AM noise the paper puts forward a novel scheme which adopts circularly polarized on-resonance light pumping and linearly polarized frequency-detuning laser probing. The transmission beam is divided into transmission and reflection beams by a polarization analyzer, the angle between the analyzer's transmission polarization axis and frequency-detuning laser polarization direction is set to 45°. The magnetic-field-sensitive signal is extracted by polarization rotation enhancement of frequency-detuning laser which induces two beams intensity difference increase as the atomic polarization increases. Therefore, AM and FM-AM noise in two beams are common-mode and can be almost entirely canceled by differential detection. We have carried out an experiment to study our scheme. The experiment reveals that the noise in the differential signal is obviously smaller than that in each beam. The scheme is promising to be applied for developing more sensitive chip-scale magnetometer.

Keywords : atomic magnetometer, chip scale, differential detection, spin-exchange relaxation free
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