Optical magnetometry using sodium fluorescence with synchronous modulation of two resonant light fields

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Remote sensing of geomagnetic field using mesospheric sodium atoms have recently received considerable attention [1-2]. This method is based on the measurement of spin precession of mesospheric sodium atoms by polarizing them through synchronous optical pumping with a modulated laser beam in a Bell-Bloom geometry [3]. These sky experiments opens up the possibility to determine large-scale ocean currents, mapping local current structures in the dynamo region, and magnetic structures in the earths upper mantle [4-5]. Currently, magnetic-field measurement sensitivity in the sky experiments is very low compared to the laboratory based atomic magnetometers [6]. Thus, new techniques need to be explored to improve the sensitivity further in a remote magnetometer. We report a new technique generating a magnetic resonance with synchronous modulation of two resonant light fields in the laboratory. The magnetic resonance is observed when light modulation frequency matches with Larmor frequency Ω_L of corresponding applied magnetic field. Unlike the Bell-Bloom geometry with a single modulated field, an additional resonance at $3\Omega_L$ is also observed in our geometry, which can be used to determine the magnetic field orientation. An average magnetic field sensitivity of 41 pT/Hz is measured using light duty cycles ranging from 35% to 10% [7].

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