Spin-Based Gyros and Magnetometers

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ABSTRACT

Quantum sensing based on optically pumped, warm-alkali vapor is quickly becoming a viable alternative to existing methodologies for a variety of sensing applications, such as magnetoencephalography (MEG) and magnetic navigation. Leveraging enabling technologies such as anodically bonded cells and miniature integrated laser packages, such as those developed during the successful chip-scale atomic clock research in the early 2000's, researchers can now make spin-based portable magnetometers that operate with high-performance in real-world, noisy environments. A brief review will be given of these developments, and discuss their impact on fundamental 'beyond the standard model' (BSM) experiments such as room-temperature neutron electric dipole moment (nEDM) searches at the Los Alamos National Laboratory. By including hyperpolarized noble gas nuclear spins with ultra-long quantum coherence times (on the order of hours to days) with alkali detection, miniature long-term stable magnetometers and inertial sensors can be made. These long-term stable systems are also being used in exotic physics searches, such as those for axions and spin-gravity coupling. We detail various modes of operation for dual noble gas quantum gyroscopes, and discuss some implications on BSM searches.

BIO

Dr. Mark E. Limes is a quantum sensing expert, specializing in sensitive alkali and hyperpolarized noble-gas measurements for magnetometry and inertial sensing. In the private sector, and as a postdoc in the Romalis group at Princeton University, he has contributed to many DARPA programs, including C-SCAN, AMBIIENT, and QUIVER, as well as various ONR and AFOSR programs, and helped detect the first unshielded magnetoencephalography (MEG) brain signals using a portable atomic magnetometer. Dr. Limes received his Ph.D. in physics from the University of Utah under Prof. Brian Saam, researching spin-exchange optically pumped noble gas nuclei, as well as optically and electrically detected organic semiconductors.