The self-compensating magnetometer for GNOME

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The Global Network of Optical Magnetometers for Exotic physics search (GNOME) [1] is a terrestial network of synchronised optical magnetometers searching for exotic spin couplings. Such couplings may be, for example, induced by topological dark matter. Interaction with the matter would impose a torque on spins, which would manifest as a change of the optical signal of a magnetometer. Currently, the main detection targets of the GNOME are domain-walls of so-called axion-like field [2] and axion Q-balls (dark-matter stars and planets) [3].

Up to date, the GNOME has been using conventional magnetoemeters (e.g. AM NMOR, Mx) [4], which are predominantly sensitive to magnetic fields. The sensitivity leads to limitation of long-term stability of the magnetometer which originates from both Johnson noise in the magnetic shield used for isolation from uncontrollable environment and thermal drifts of the current source used for compensating coils.

In order to improve long term stability and sensitivity of the network in the next incarnation of the network it is planned to introduce a new sensor type. The sensor will be based on the mechanism of self-compensation developed by Romalis and co-workers [5]. We will report on the progress on the construction of the first such sensor for the GNOME.

The self-compensating magnetometer operates based on coupled evolution of two atomic species. Our magnetometer employs rubidium vapour and ^{3}He gas contained in a spherical glass cell heated to about 190°C. Both of them are polarized with hybrid optical pumping, which allows their strong and homogeneous polarization. The system, exposed to external magnetic field, is a subject of complicated nonlinear evolution. In particular, under certain longitudinal magnetic field (so-called compensation field), Rb becomes insensitive to slow drifts of the external magnetic field perpendicular to the compensation field, becoming sensitive to nonmagnetic field couplings. It makes this setup effective for topological dark matter searches provided by the GNOME.

We will present an experimental setup, enabling operation in self-compensating regime, and various studies analysing the role of different experimental parameters in the magnetometer performance.

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