Cesium atomic magnetometers in experiment searching for a neutron electric dipole moment

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The existence of a non-zero neutron electric dipole moment (nEDM) violates both parity (P) and time reversal (T) invariance and, through the conservation of the combined symmetry CPT, also violates CP symmetry (C being the charge conjugation operator). The violation of CP symmetry is one of the possible explanations why there is almost no antimatter in the Universe. The CP violation mechanism is implemented in the Standard Model of particle physics, however it is not sufficient to explain the matter - antimatter asymmetry. The theories beyond the Standard Model, such as Supersymmetry, contain additional sources of CP violation and predict the nEDM in the range $10^{-27} - 10^{-29} e \cdot cm$ [1], considerably larger that the value predicted by the Standard Model ($10^{-31} e \cdot cm$ [1]).

In the nEDM experiment at the Paul Scherrer Institute in Switzerland, the Ramsey technique of (time-)separated oscillatory fields [2] is applied to the polarized neutrons exposed to magnetic B and electric E fields oriented either parallel(+) or anti-parallel (-). Any non-zero difference in the neutron precession frequency ν_L between the two field configurations will indicate the presence of a nEDM (d_n):

$$\frac{h}{4E}(\nu_L^+ - \nu_L^-) = d_n + \mu_n \frac{B^+ - B^-}{2E}, \tag{1}$$

where μ_n is the magnetic moment of a neutron. The spatial and temporal magnetic field distribution has to be precisely known in order to sufficiently suppress any systematic effects associated with field changes. The array of sixteen Cesium magnetometers located around the neutron precession chamber is measuring the stability of the magnetic field in time and its spatial distribution (Fig. 1). The principle of magnetic field measurements is based on the optical detection of the Larmor precession frequency of the polarized Cs atoms. The Cs atoms, confined in a paraffin coated glass cell of 30 mm diameter [3], are spin polarized by the resonant laser light by means of optical pumping. A weak oscillating magnetic field (rf field) resonantly drives the spin precession at the Larmor frequency. The magnetic field measurements are done in the fast(ms) high sensitivity phase-stabilized mode [4]. In this contribution the current status of the nEDM experiment will be discussed, with a focus on the Cs magnetometry aspects.

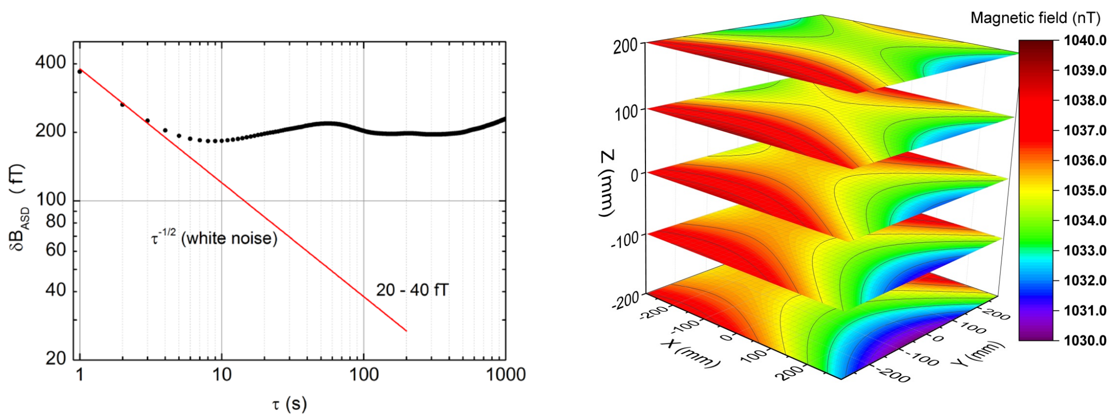

Figure 1: *Left: Allan standard deviation versus averaging time measured for Cs magnetometer. Right: Magnetic field map derived by multipole moment fit [5] to all Cs data.*

References
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