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Offline Characterization of a Highly Uniform Magnetic Field for the n2EDM Experiment

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The n2EDM experiment at the Paul Scherrer Institute (PSI) aims to improve the sensitivity to the neutron electric dipole moment (nEDM) by an order of magnitude relative to the current best limit ($1.8 \times 10^{-26}\ e \cdot \mathrm{cm}$). A key requirement to achieve this goal is the generation and precise control of a highly homogeneous static magnetic field B_0 within the precession volume. Magnetic field non-uniformities directly affect the statistical sensitivity and introduce systematic errors into the measurement.

Consequently, the magnetic field requirements are stringent. In particular, to suppress the so-called false EDM effect, a systematic shift arising from the use of a mercury co-magnetometer, higher-order odd gradients (e.g., $G'_{3,0}$, $G'_{5,0}$, $G'_{7,0}$) must be reproducible at the level of
$lesssim 23\ \mathrm{fT/cm}$, thereby limiting the associated false EDM contribution to below $3 \times 10^{-28}\ e \cdot \mathrm{cm}$ [1].

To verify that these criteria are fulfilled under operating conditions, we conducted a comprehensive magnetic field mapping campaign inside the magnetically shielded room (MSR) of the n2EDM experiment, employing a robotic field mapper that had recently undergone hardware and software upgrades.

We present recent results confirming that the design goals for field uniformity and gradient control, as outlined in [2], are met. In addition, we report field maps of the "magic field" configuration, at which the total false EDM is reduced by an order of magnitude. These data provide important input for the physics data-taking phase of n2EDM and confirm the compatibility of the magnetic field environment with the targeted experimental sensitivity of $1 \times 10^{-27}\ e \cdot \mathrm{cm}$.

References

[1]: C. Abel *et al.*, "Generating a highly uniform magnetic field inside the magnetically shielded room of the n2EDM experiment", *Eur. Phys. J. C* **85**, 202 (2025). https://doi.org/10.1140/epjc/s10052-025-13902-x

[2]: N. J. Ayres *et al.*, "The design of the n2EDM experiment", *Eur. Phys. J. C* **81**, 512 (2021). https://arxiv.org/abs/2101.08730

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