Minimizing the Magnetic Contamination inside the n2EDM experiment

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The n2EDM experiment

- measures the permanent electric dipole moment (EDM) of the neutron via the Larmor frequency:

$$f_n = \frac{1}{\pi\hbar}\left|\mu_n \vec{B}_0 \pm d_n \vec{E}\right|$$

- Current limit: $d_n < 1.8 \times 10^{-26} e$.cm (90% C.L.) [1]
- n2EDM goal sensitivity to $d_n = 1 \times 10^{-27} e$.cm [2]
  - ➢ magnetic field stability and uniformity.

The false EDM effect

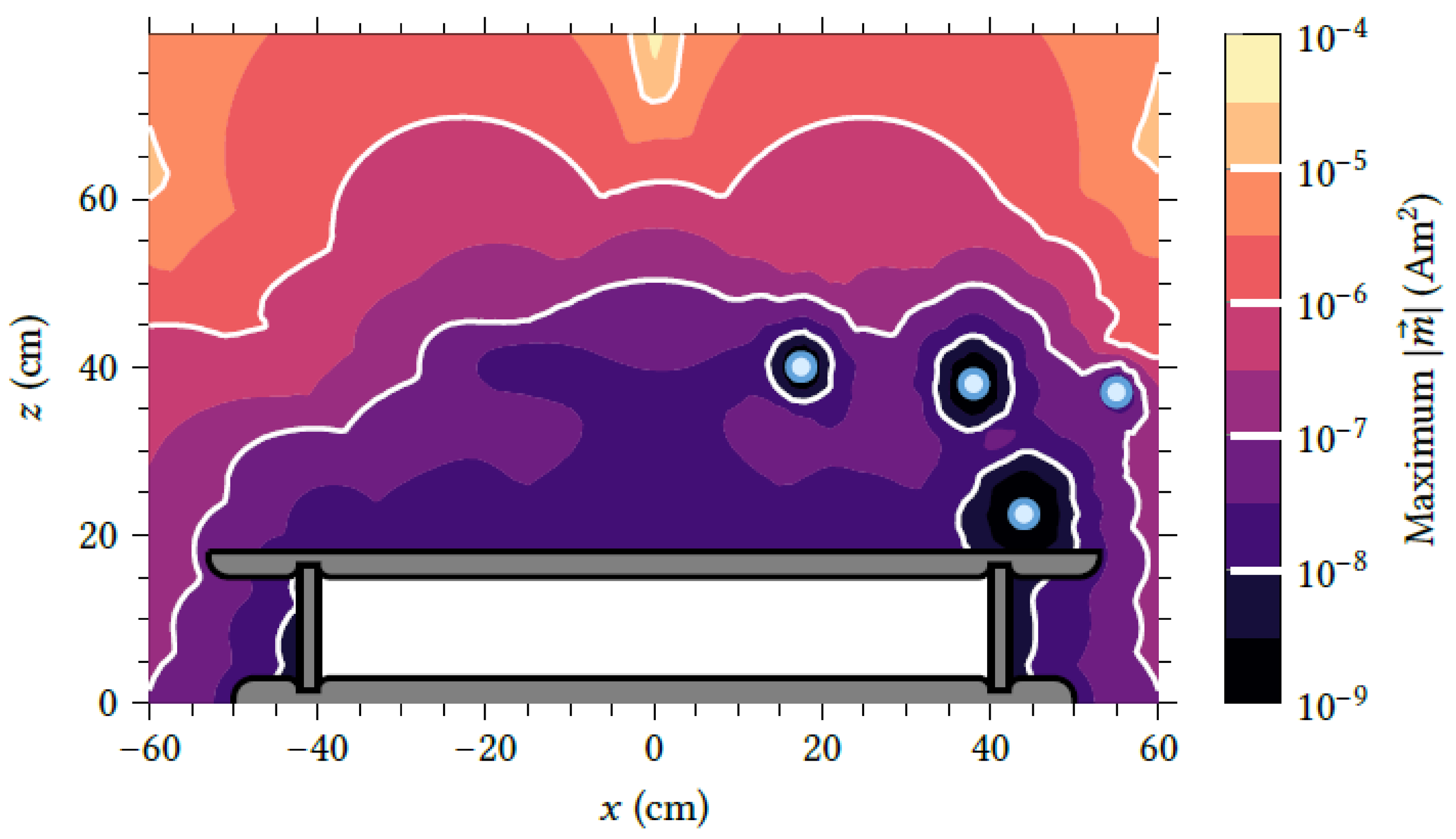
- Motional magnetic field:

$$\vec{B}_m = \vec{E} \times \frac{\vec{v}}{c^2}$$

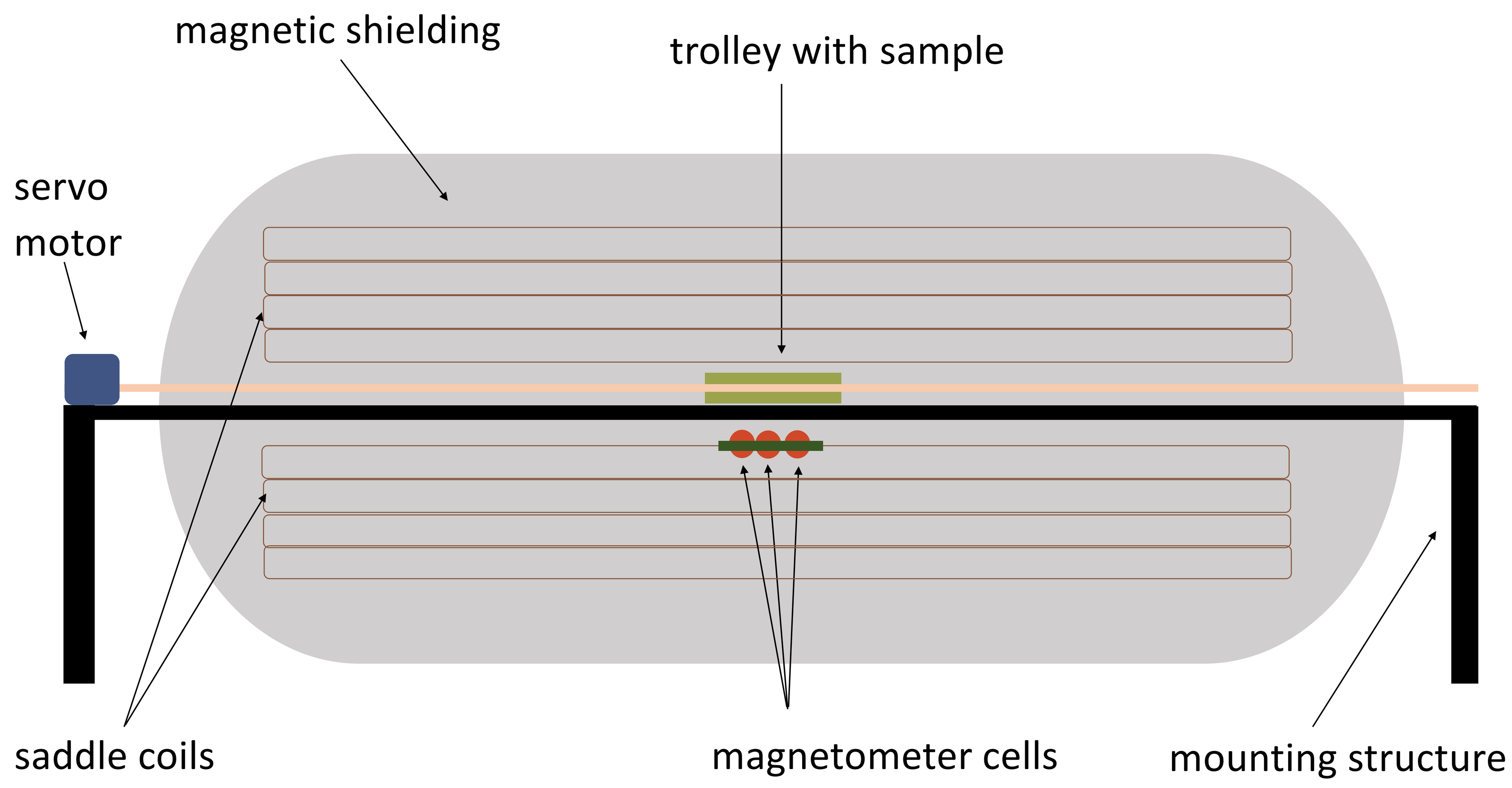
- mercury atoms lead to an induced false neutron EDM [3]:

$$d_{n\leftarrow Hg}^{false} = \left|\frac{\gamma_n}{\gamma_{Hg}}\right| d_{Hg}^{false}$$

- Global gradient fields can be corrected for; except: local contaminations



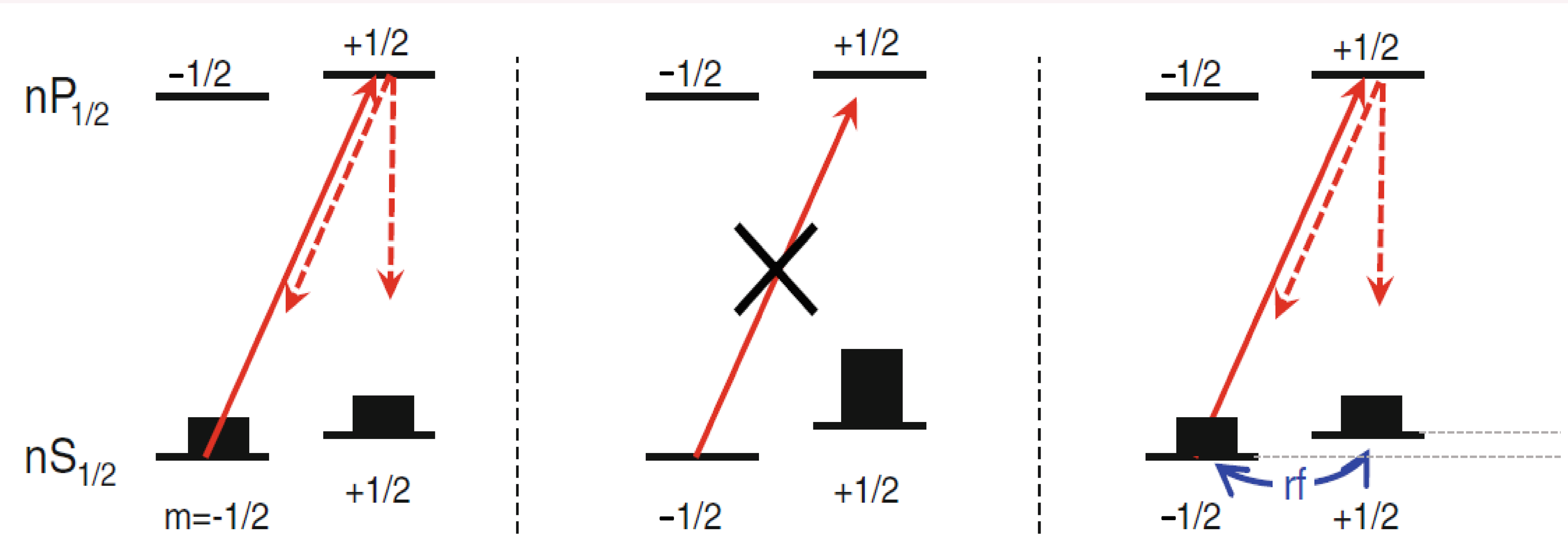
Analysis of the maximum allowed magnetic dipole contamination for a dipole shift of $\Delta d \leq 3 \times 10^{-28}$ e.cm [4].

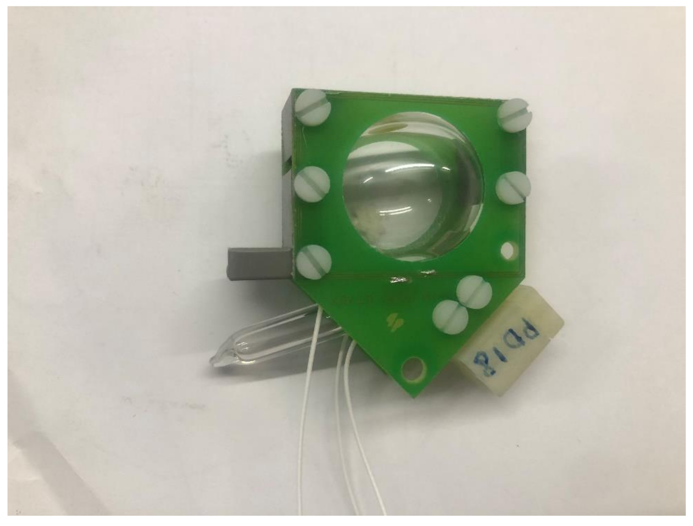


A sketch of the gradiometer design.

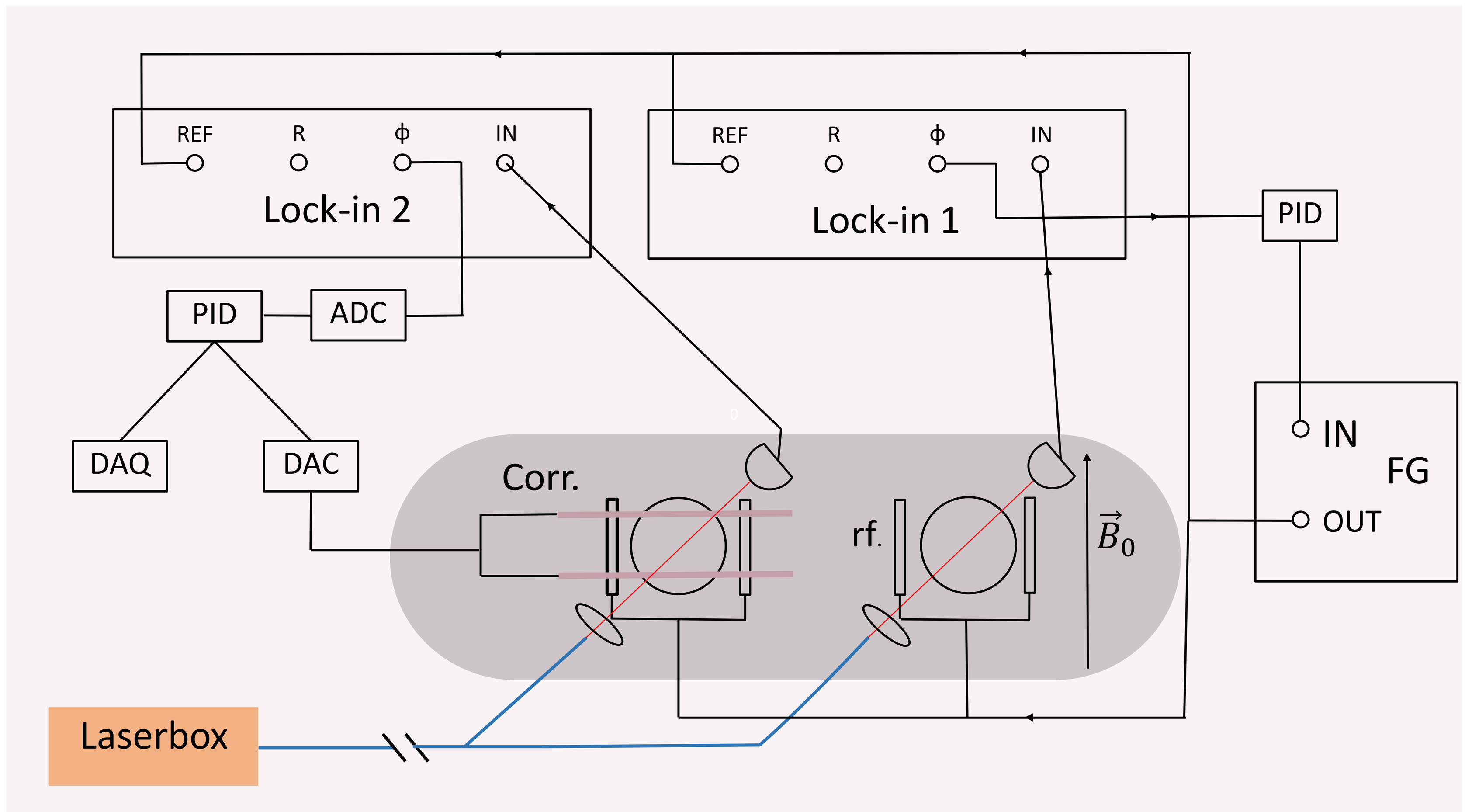
Caesium magnetometry [5]

- Optical pumping (σ^+)
- F = 4 -> F' = 3
- Driven re-absorption using oscillating field

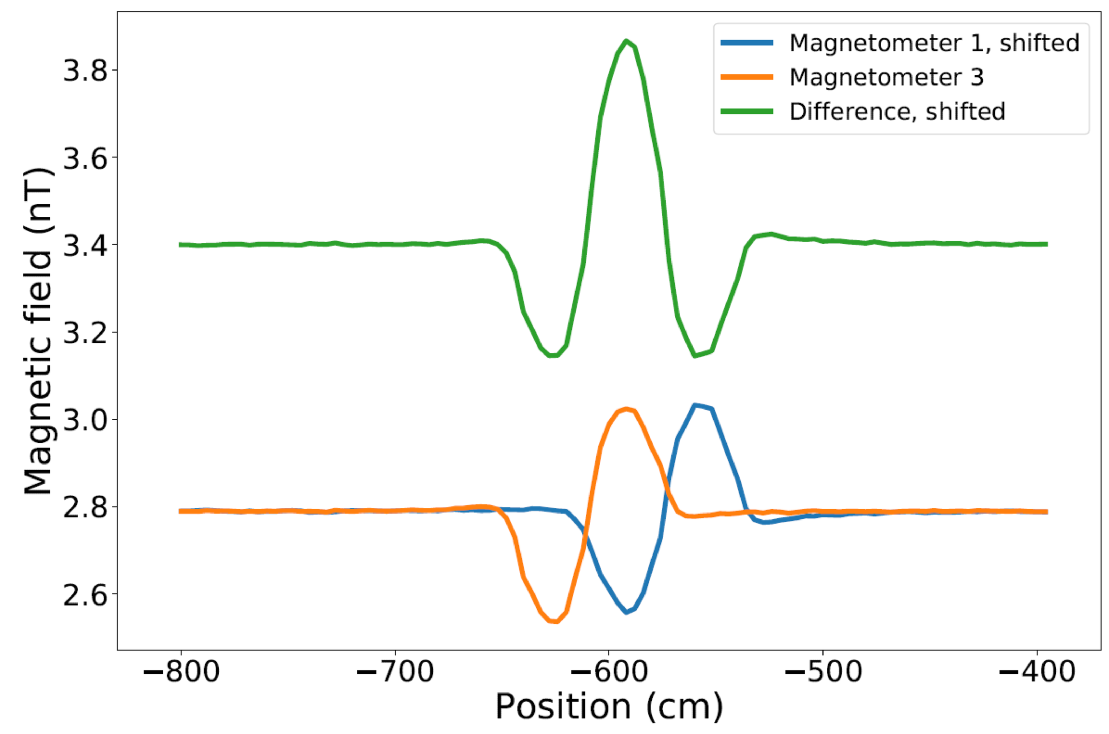




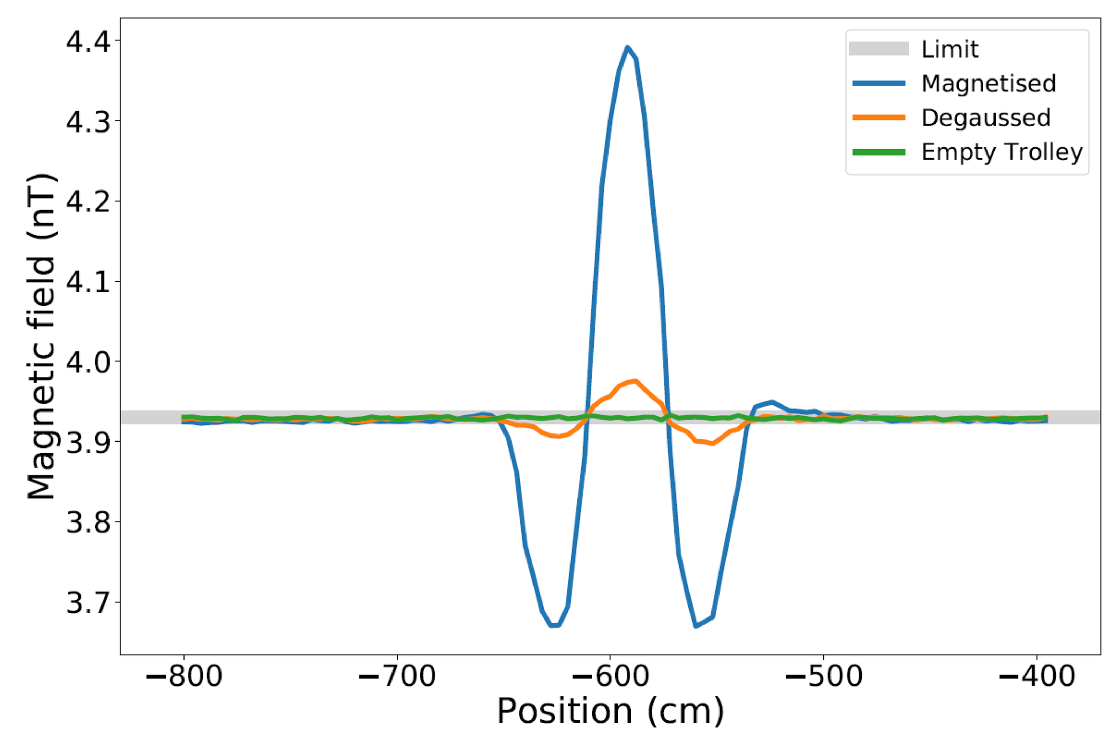
Single caesium magnetometer cell and view into the gradiometer with sample piece on the trolley



Working principle of the array.



Measurement of n2EDM part: individual magnetometer responses and gradiometer mode



A sample measurement of a part displaying magnetic contamination.

Outlook

- Improve noise to ~ pT
- Automatic fit of measured field → magnetic dipole moment

References

[1] C. Abel *et al.*, Measurement of the Permanent Electric Dipole Moment of the Neutron, Phys. Rev. Lett. 124, 081803, 2020.

[2] N. J. Ayres *et al.*, The Design of the n2EDM experiment, EPJ C, 2021.

[3] C. Abel *et al.*, Magnetic field uniformity in neutron electric-dipole-moment experiments, Phys. Rev. A 99, 042112, 2010.

[4] D.A. Pais, Development of the caesium magnetometer array for the n2EDM experiment, Diss. ETH No. 27742, 2021.

[5] Adapted from A. Weis, G. Bison, Z.D. Grujic, Magnetic Resonance Based Atomic Magnetometers, in *High Sensitivity Magnetometers*, Springer 2017.