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Probing the axion gradient-coupling with nuclear magnetic resonance spectroscopy

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The cosmic axion spin precession experiment (CASPEr) is a nuclear magnetic resonance (NMR) experiment to search for axion and axion-like particles (ALPs) [1]. With the CASPEr-Gradient setups in Mainz we aim to probe the coupling of nuclear spins to the gradient of the ALP field for the mass range of approximately 10^-13 to 10^-6 eV, corresponding to the Compton frequency range of 100 Hz to 600 MHz. In this presentation, we describe the two setups and the considerations that have led to the current design, followed by a status update and outlook. These will all be related to our recent work on sensitivity limits of NMR [2], spectral signatures of the ALP signal [3], and stochastic properties of the ALP field [4].

[1] D.F. Jackson Kimball, et al. "Overview of the Cosmic Axion Spin Precession Experiment (CASPEr)."In Microwave Cavities and Detectors for Axion Research, edited by Gianpaolo Carosi and Gray Rybka, 105–21. Springer Proceedings in Physics. Cham: Springer International Publishing, 2020.
[2] D. Aybas, et al. "Quantum Sensitivity Limits of Nuclear Magnetic Resonance Experiments Searching for New Fundamental Physics."Quantum Science and Technology 6, no. 3 (June 15, 2021): 034007.
[3] A.V. Gramolin, et al. "Spectral Signatures of Axionlike Dark Matter."Physical Review D 105, no. 3 (February 24, 2022): 035029.
[4] G.P. Centers, et al. "Stochastic Fluctuations of Bosonic Dark Matter."Nature Communications 12, no. 1 (December 16, 2021): 7321.

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