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Interface Between the Xenon-129 Polarizer and NMR Spectrometer in the CASPEr Dark Matter Experiment

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An overview of hyperpolarized Xe transport and sample preparation as part of our experimental program to search for QCD axions and axion-like particles (ALPs) as possible candidates for DM using NMR techniques within the cosmic axion spin precession experiment (CASPEr) is presented [1]. The NMR signals from these particles will be very weak so all possibilities for signal enhancement need to be considered and for that, the chosen nuclei are 129-Xe that are hyperpolarized using the spin-exchange optical pumping (SEOP) technique inside a large optical cell. In this method, polarization is transferred to Xe via Fermi contact interactions with an optically pumped alkali metal. Especially for investigations of the nuclear spin resonance of liquid Xe as a fundamental physics experiment, a non-metallic variable temperature insert (VTI) is needed. This VTI should be suited for immersion in liquid helium. The sapphire sample holder is to hold on a level of 165 K ±1 K by a gaseous flow of temperature-stabilized nitrogen. Xe has a much higher spin density when it is liquid, thus it has to be kept in that narrow temperature range. The hyperpolarized Xe is then to be placed in a magnetic field that will be scanned up to 14.1 T looking for a possible resonance with the axion field, while the Xe nuclei undergo precession due to the gradient interaction. The first-generation experiments aim to explore many decades of ALP parameter space beyond the current astrophysical and laboratory bounds in the mass range of approximately 10-11 to 10-6 eV.

[1] Derek 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.

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