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Searching for dark matter with comagnetometers

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Self-compensated comagnetometers, employing overlapping samples of spin-polarized alkali and noble gases are promising sensors for exotic beyond-the-standard-model fields and high-precision metrology such as rotation sensing.

We use comagnetometers to perform an Axion-like particle (ALP) dark matter search. We search through the ALP-nucleon interaction by interfering the signals of two atomic K-Rb-^{3}He comagnetometers, with one situated in Mainz, Germany, and the other in Kraków, Poland. ALPs arise from well-motivated extensions to the Standard Model and could account for dark matter. ALP dark matter would manifest as a nearly monochromatic field oscillating at an as of yet unknown frequency. The frequency depends on the ALP mass, which could plausibly range from 10^{-22} eV/c^2 to 10 eV/c^2. The search extends over nine orders of magnitude in ALP mass. In this range, no significant evidence of an ALP signal is found. We thus place new upper limits on the ALP-neutron, ALP-proton and ALP-electron couplings reaching below $g_{aNN} < 10^{-9}$ GeV^{-1}, $g_{aPP} < 10^{-7}$ GeV^{-1} and $g_{aee} < 10^{-6}$ GeV^{-1}, respectively. These limits improve upon previous laboratory constraints for neutron and proton couplings by up to three orders of magnitude.

Moreover, I will discuss the role of parametric modulation of the leading field to reduce the noise in such quantum sensors.

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