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A Search for Axion-like Particles with a Horizontally Polarized Beam In a Storage Ring

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A new method has been demonstrated using the storage ring COSY to search for an axion-like particle by scanning for a resonance in the horizontal-plane rotation of the deuteron beam polarization. If an electric dipole moment (EDM) is present on the nucleus, the radial electric field that exists in the particle frame will create a rotation of the polarization out of the horizontal plane and into the vertical direction. If that EDM oscillates due to the presence of an axion-like field in synchronization with the rotation of the polarization, then the vertical rotation will accumulate near the resonance, producing a measurable vertical polarization component. In the spring of 2019, we used a 0.97-GeV/c vector-polarized deuteron beam to successfully demonstrate the procedure for the search. The phase of the oscillating EDM with respect to the rotation of the polarized beam in unknown. In order to be sensitive to both cosine and sine components of the oscillation, we prepared four bunches for the ring with different polarization directions. Starting with vertical polarization following injection into the ring, an RF solenoid operating on the $(1 + G\gamma)$ harmonic of the beam revolution frequency was used to rotate the polarization into the horizontal plane. This yielded a polarization pattern in which two of the bunches had polarizations that were nearly orthogonal. By looking separately for signals on both bunches, a signal would be found for any value of the axion phase. Beam polarizations were measured using the WASA Forward Detector. In order to improve the horizontal polarization lifetime, the beam was electron cooled as well as bunched. Once the orbit was established with minimal steering corrections, the ring sextupole magnets were adjusted to maximize the horizontal polarization lifetime. All scans were made with lifetimes in excess of 500 s. The sensitivity to an axion was tested and calibrated using the magnetic field of a horizontally mounted RF Wien filter to create vertical polarization jumps during a frequency scan of COSY. In a series of scans spanning a 1.5% change in the neighborhood of 120 kHz, no signals were seen that did not fit the statistical distribution that arises from event counting data collection. In this case, the sensitivity to an oscillating EDM approached 10^{-22} e·cm.

Summary

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