Contribution ID: **345** Type: **Talk**

New method to search for axion-like particles demonstrated at the COSY storage ring

Sunday 5 September 2021 14:06 (18 minutes)

The axion was originally proposed to explain the small size of CP violation in quantum chromodynamics. The axion would have a small mass and be weakly coupled to nucleons. If sufficiently abundant, it might be a candidate for the dark matter in the universe. Axions or axion-like particles (ALPs), when coupled to gluons, induce an oscillating Electric Dipole Moment (EDM) along the nucleon's spin direction. This can be used in an experiment to search for axions or ALPs using polarized charged particles in a storage ring.

In the spring of 2019, at the Cooler Synchrotron (COSY) in Jülich, we performed a first test experiment to search for ALPs using an in-plane polarized deuteron beam with a momentum of 0.97 GeV/c. The field of the ring magnets precesses the deuteron polarization in the horizontal plane relative to the beam velocity at a rate determined by the deuteron anomalous magnetic moment multiplied by the relativistic factor γ. In the frame of the moving beam, the radial electric field due to the ring magnets ($\mathbf{v} \times \mathbf{B}$) rotates the EDM. If the spin precession frequency equals the EDM oscillation frequency, which is proportional to the ALP mass, a resonance occurs that accumulates the rotation of the polarization out of the ring plane. This rotation is detected with a polarimeter that measures the transverse components of the beam polarization while the beam is stored. Since the axion frequency is unknown, the momentum of the beam was slowly ramped, thus changing γ, to search for a vertical polarization jump that would occur when the resonance is crossed. At COSY, four beam bunches with different polarization directions were used to make sure that no resonance was missed because of the unknown relative phase between the polarization precession and the EDM oscillations. We scanned a frequency window of about a 1 kHz width around the spin precession frequency of 121 kHz. This talk will describe the experiment and show preliminary results.

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Session Classification: Dark matter and cosmology

Track Classification: Dark matter and cosmology