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Storage ring searches for ALPs – experimental proof of principle

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Axions, originally introduced to address the strong CP problem in quantum chromodynamics, if sufficiently abundant, are a compelling candidate for dark matter. Axions or axion-like particles (ALPs), as components of the cold dark matter in our Galaxy, can be treated as a classical field. These ALPs are theorised to couple to the spin of nucleons and nuclei either directly, via the axion wind effect, or indirectly by inducing an oscillating electric dipole moment (EDM) in nucleons. This coupling mechanism provides a novel approach to search for ALPs using a storage ring, circulating with a beam of in-plane polarized hadrons, as an antenna. When the spin-precession frequency of the beam matches the ALP field frequency, a resonance occurs, leading to a build-up of the polarisation out of the ring plane, which is a signal for ALPs. Since the ALP mass and corresponding frequency are unknown, the resonance search is conducted by varying the beam momentum, which directly relates to the spin-precession frequency.

The JEDI collaboration performed a proof-of-principle experiment to validate this approach at the Cooler Synchrotron (COSY) in Juelich, targeting an ALP mass range of $0.495 - 0.502\,\mathrm{neV}/c^2$. While no ALP signal was observed, the experiment established a 90% confidence upper limit on the oscillating EDM at $6.4\times10^{-23}\,e\cdot\mathrm{cm}$. Additionally, the experimental method was successfully tested by introducing a simulated ALP signal in the ring using a radio-frequency Wien filter. In this talk, I will detail the experiment and discuss the result.

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