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The acceleration and spin direction control of tensor-polarized deuteron beams in a synchrotron

To investigate the internal spin structure of nucleons and explore fundamental phenomena such as parity and time-reversal symmetry violations, polarized deuteron beams play a pivotal role as they serve as a unique substitute for polarized neutron beams and enable access to tensor polarization—a critical feature of spin-1 systems that provides distinct insights beyond vector polarization. This study advances the understanding of tensor-polarized deuteron beam dynamics in synchrotrons, with direct relevance to the Electron-Ion Collider in China (EicC). By deriving spin tensor transfer matrices and validating their accuracy through numerical simulations, we demonstrate tensor polarization evolution in bending magnets, solenoids, and quadrupoles. The analysis of depolarizing resonances during acceleration reveals negligible polarization losses under the EicC' s operational parameters, ensuring the feasibility of high-precision spin experiments without dedicated polarization maintenance. Furthermore, the planar-constrained translational dynamics of spin tensors, fundamentally distinct from the rotational mechanisms governing spin vectors, offer novel strategies for spin manipulation in future accelerators. These results provide theoretical and computational foundations for spin tensor control in the EicC and broader applications in spin-correlation experiments.

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