Study of spin-orbit motion in the Frozen and Quasi-Frozen rings

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1 Spin decoherence effect in a perfectly aligned storage ring

We study decoherence for two major reasons:

1. it reduces the measurement time frame;
2. vertical plane decoherence is a source of systematic error. [3, p. 8]

Here we consider the decoherence resulting from the beam particles' spin tune difference.

The spin dynamics in a storage ring is governed by the FT-BMT equation, [1, p. 4] In the standard spinor formalism, spin evolution is described by a rotation matrix, whose eigenvector is the spin precession axis, $\bar{n}$, and eigenvalue the spin tune, ν_s. For particles traveling along the design orbit of a perfectly aligned, flat storage ring, the equilibrium direction of $\bar{n}$ is vertical. [2, p. 1362] The spin tune expressions in the electric and magnetic fields are: [3, p. 8]

$$\nu_s^E = \left(\frac{1}{\gamma^2 - 1} - G\right)\gamma\beta^2, \tag{1}$$

$$\nu_s^B = \gamma G, \tag{2}$$

where $G = \frac{g-2}{2}$ is the magnetic moment anomaly, $\gamma = (1-\beta^2)^{-1/2}$ is the particle's Lorentz factor.

The phase stability principle requires that orbit lengthening is accompanied by a corresponding equilibrium energy shift [4]. This means that particles traveling on different orbits will have differring spin tunes, hence decoherence. Orbit lengthening is due to two reasons: a) betatron motion, b) momentum deviation.

2 Decoherence suppression via sextupole fields

Sextupole fields influence orbit lengthening via two paths:

1. by affecting the momentum compaction factor: $\delta\alpha_1 = -\frac{S\cdot D_0^3}{L}$
2. by directly changing the orbit length: $\frac{\Delta L}{L} = \mp\frac{S\cdot D_0\cdot\beta_{x,y}\varepsilon_{x,y}}{L}$.

3 Simulation design

4 Simulation results

References

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