Spin Tracking with "Real" Siberian Snakes in RHIC

Meiqin Xiao* and Takeshi Katayama**

*Fermi National Accelerator Laboratory, e-mail: meiqin@fnal.gov

**Center for Nuclear Study (CNS), the University of Tokyo/RIKEN

Abstract

The numerical study of the spin depolarization in Relativistic Heavy Ion Collider(RHIC) at BNL due to the intrinsic and imperfection resonances has been carried out by tracking the orbital and spin motion of polarized protons with "real" Siberian Snakes in the ring, based on the magnetic field-map produced by TOSCA calculation, from the injection energy of 25GeV to the top energy of 250GeV. Firstly, the energy-dependent numerical orbital maps and the spin matrices of a Siberian Snake have been obtained by a method to combine spline interpolation functions for magnetic field fitting and TPSA (Truncated Power Series Algebra or Automatic Differentiation) approach for extracting an exact orbital map around any ray. Secondly, the symplectic problem of orbital map was solved for the spin tracking for 10^7 turns. And then, the code SPINK was upgraded to carry out spin tracking. Finally, the numerical spin tracking in RHIC with "real" Siberian Snakes was carried out. The single- and multi- particle tracking results show that "real" Siberian Snakes can keep the polarization of the protons through the acceleration to more than 95% in a RHIC machine with no misalignment and no field error, if the polarized protons are extracted from the emittance of 10πmm.mrad. In the machine with misalignments, it is found that the bigger the misalignments, the stronger the depolarization resonances. If r.m.s. misalignment is as large as 2.5mm, the corrected closed orbit distortion should be less than 0.2mm in the ring. The average polarization in this condition is about 73% at the top energy. On the other hand, it was found that "real" Siberian Snakes introduce the coupling of horizontal and vertical betatron motions in the low energy region. The operation points cross 10^{th} order and 5^{th} order sum resonance lines and difference resonance line during the acceleration. However, these motions in the low energy region do not affect so seriously the spin polarization.