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BNL alternating gradient synchrotron with four helical magnets to minimize the losses of the polarized proton beam

The principle of using multiple partial helical magnets to preserve the polarization of the proton beam during its acceleration was applied successfully to the alternating gradient synchrotron (AGS) which currently operates with two partial helical magnets. In this paper we further explore this idea by using four partial helical magnets placed symmetrically in the AGS ring. This provides many advantages over the present setup of the AGS, which uses two partial helical magnets. First, the symmetric placement of the four helical magnets and their relatively lower field of operation allows for better control of the AGS optics with reduced values of the beta functions, especially near beam injection and allows both the vertical and horizontal tunes to be placed within the ''spin tune gap,'' therefore eliminating the horizontal and vertical intrinsic spin resonances of the AGS during the acceleration cycle. Second, it provides a wider spin tune gap. Third, the vertical spin direction during beam injection and extraction is closer to vertical. Although the spin tune gap, which is created with four partial helices, can also be created with a single or two partial helices, the high field strength of a single helical magnet which is required to generate such a spin tune gap makes the use of the single helical magnet impractical, and that of the two helical magnets rather difficult. In this paper we will provide results on the spin tune and on the optics of the AGS with four partial helical magnets, and compare them with those from the present setup of the AGS that uses two partial helical magnets. Although in this paper we specifically discuss the effect of the four partial helices on the AGS, this method which can eliminate simultaneously the vertical and horizontal intrinsic spin resonances is a general method and can be applied to any medium energy synchrotron which operates in similar energy range like the AGS and provides the required space to accommodate the four helices. In addition, the four partial helix solution is an optimum solution because it eliminates all the spin resonances for any synchrotron which operates in the same energy range as the AGS.

Primary author: Dr TSOUPAS, Nick (Brookhaven National Lab)

Co-authors: Dr MONTAG, Christoph (Brook National Lab); Dr TRBOJEVIC, Dejan (Brookhaven National Lab); HUANG, Haixin (Brookhaven National Lab); Dr ROSER, Thomas (Brookhaven National Lab)

Presenter: Dr TSOUPAS, Nick (Brookhaven National Lab)

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