**Simulating Proton Beams in the Integrable Optics Test Accelerator**

**Abstract:**

We present initial simulations of 2.5 MeV proton beams in the IOTA ring [1], including significant tune depression due to space charge. The beam dynamics will be studied for the linear lattice and with strong nonlinear magnets that are designed to preserve one or two invariants of the motion.

**Summary:**

The concept of nonlinear integrable optics [2] shows promise for introducing order unity tune spread with large dynamic aperture, which can suppress space charge driven parametric resonances and associated beam loss via halo formation [3]. The Integrable Optics Test Accelerator (IOTA) is a novel ring designed [1] to explore these concepts, initially with low-charge electron bunches and subsequently with low-energy proton beams that include significant tune depression due to space charge. IOTA is part of the Advanced Superconducting Test Accelerator (ASTA) [4] at Fermilab.

We will present initial simulations of 2.5 MeV proton beams in IOTA, using an earlier lattice design that enables use of four straight sections with strong nonlinear magnetic elements – either variable strength octupoles or the more exotic high-order element that is now under construction [5]. The idealized beam dynamics with 2D space charge forces will be compared in the linear and nonlinear lattices for both low-current and high-current.

[1] A. Valishev et al., “Beam Physics of Integrable Optics Test Accelerator at Fermilab,” Proc. IPAC, TUPPC090 (2012).

[2] V. Danilov and S. Nagaitsev, Phys. Rev. ST-AB 13, 84002 (2010).

[3] S. Webb et al., “Effects of Nonlinear Decoherence on Halo Formation” (2013), submitted to PRSTAB; http://arxiv.org/abs/1205.7083  
  
[4] Advanced Superconducting Test Accelerator (ASTA); <http://asta.fnal.gov/>

[5] F. O‘Shea, "Non-linear IOTA inserts," presented at 2nd ASTA Users Meeting (Fermilab, June 2014).