Integrable Optics Test Accelerator (IOTA)

- Storage ring for advanced beam physics
- Stores proton and electron beams
- Currently running experiments with electrons
- Small and can be easily reconfigured to accommodate a wide-ranging experimental program

IOTA Proton Beam Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Beam Kinetic Energy, E</td>
<td>2.5 MeV</td>
</tr>
<tr>
<td>Beam Intensity, N</td>
<td>9 x 10^{15}</td>
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<tr>
<td>Normalized Emittance, e</td>
<td>0.3 μm</td>
</tr>
<tr>
<td>Tune Shift (coasting, bunched)</td>
<td>-0.5, -1.2</td>
</tr>
<tr>
<td>Space Charge Perveance (coasting, bunched)</td>
<td>1.3 x 10^{-6}, 6.06 x 10^{-6}</td>
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- Emittance growth is significantly reduced for the coating beam as the perveance is about 5 times smaller

Integrable Optics

- Space charge defocuses the beam, causing tune spread to grow and particles to hit resonances and get lost
- Integrable optics might remedy this by suppressing single particle resonances with a nonlinear focusing force
- Full integrability can be achieved with specially profiled nonlinear magnets and partial integrability can be achieved with a sequence of conventional octupole magnets
- Integrability is a property of single particle motion, and space charge introduces a perturbation that has the potential to destroy the favorable features of integrability

Purpose of Project

- The goal of the project is to test if these optics can mitigate space charge driven resonances and retain the benefits of integrability while keeping loss at an acceptable level
- Simulations are performed with PyORBIT, a PIC code for multi-particle tracking that models space charge effects

Methods

- Particles are tracked for 1000 turns about the IOTA lattice
- Simulations have examined a bunched beam with octupoles at various strengths for reduced and full beam intensities

Results

- Even at a low intensity, the space charge force moves particles past the small dynamic aperture caused by full strength octupoles
- An attempt to account for this was made at a greater intensity by truncating the initial particle distribution:
- At full intensity, space charge results in >80% loss at full strength, even with a truncated Gaussian distribution
- Data from 1e10 intensity verifies that particles are more likely to hit the DA if they are initialized further from the beam center

Conclusions

- Due to DA reductions, partial integrability does not seem to withstand a large space charge perturbation well
- Integrability is sensitive to certain lattice specific properties, such as the phase advance outside of the nonlinear insert, which will be investigated
- Further work includes testing a uniform (as opposed to Gaussian) distribution and rematching the beam to a phase advance of 2π with space charge

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.