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(POS-4) Non-linear Optics Corrections for the Future Circular Collider Electron-Positron Collider Ring

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The Future Circular Collider electron-positron machine (FCC-ee) is a proposed successor to the Large Hadron Collider at CERN. The design is for a 91 km accelerator ring to allow particles to be accelerated to extremely high energies, ranging from 45.6 GeV to 182.5 GeV per beam in various operation schemes. Two counter-rotating beams will then be brought into collision at specific interaction points to study the standard model up to a centre of mass energy of \sqrt{s} = 365 GeV.

In order to bring these beams into collision at the interaction points, the particles are steered and focused with a ring of electromagnets. The design of the locations and magnetic fields is called the magnetic lattice, and it constrains the motion of the particles. The range of particle amplitudes and momenta relative to an ideal reference particle that can be stably stored are called the dynamic aperture (DA) and momentum acceptance (MA) respectively.

One of the major limiting factors on the DA and MA are tune resonances which cause unstable beam motion. Tune is the fractional phase advance that a particle undergoes in complete revolution of the ring. An integer tune means that the motion of a particle has the same phase each time it reaches a given location in the ring, so resonant effects of any errors in the machine quickly compound and lead to particle loss. Half-integer tunes mean every second revolution a particle has the same phase, and so on for other rational tunes. A lattice design selects a horizontal and vertical tune that avoids such resonances, but non-linear effects in the machine complicate the issue. Particles with different momenta and oscillation amplitudes are focused differently by the lattice, resulting in momentum and amplitude dependent tune shifts. The shifts can cause particles to move to resonant tunes leading to particle losses and reduced beam lifetime, which is detrimental to experimental quality.

These non-linear effects can be corrected and controlled using higher order magnetic fields which provide opposing non-linear effects to balance the unwanted tune shifts. The work presented here covers initial investigations into the use of high order magnetic fields to correct non-linear tune shifts and enhance the stability of the stored beam in the FCC-ee ring.

Keyword-1

accelerator

Keyword-2

beam dynamics

Keyword-3

non-linear optics

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