SuperKEKB Lattice translation

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Outline

➤ Introduction

➤ Current status
  ● Lattice translation without solenoid

➤ SuperKEKB lattice translation
  ● With solenoid
  ● Without solenoid

➤ Summary
1. Introduction

➤ Motivation

- Accelerator physics challenges in SuperKEKB: DA, lifetime, luminosity, background, etc.

![Graph showing specific luminosity vs. product of bunch currents for different designs.](image-url)
1. Introduction

➢ Motivation

- SuperKEKB as a demonstrator for FCC-ee

Ref. F. Zimmermann et al., IPAC’14, MOXAA01.
1. Introduction

➤ Advantages of SAD

- Symplectic integrator, optics matching, beam envelope, ...
- Advanced programming using mathematica-like script language
- Handling complicated IR (MULT elements, Arbitrary map, etc.)
- Collective effects (IBS, beam-beam, beamstrahlung, etc.)
- Other fancy features (refer to http://acc-physics.kek.jp/SAD/index.html)
2. Current status

➤ Lattice translation: MAD-X to SAD
  ● MAD-X input and sequence to SAD input
  ● Various elements: Mostly straightforward (personal understanding)
    ● Translating a CLIC FFS beam line to SAD looks successful (Working with Paul Thrane). Other cases: BEPC, ILC DR, etc.
  ● For large files, we need a translator. SAD script from H. Koiso is available, but to be generalised and improved
2. Current status

➤ A comparison of MAD-X and SAD: CLIC FFS

- Linear Twiss functions perfectly agree
- Momentum dependence of Twiss functions
2. Current status

➤ A comparison of MAD-X and SAD: CLIC FFS

- Tracking: Coordinates at IP as a response to the initial offset (by Paul Thrane)
- Nonlinear transformations for normal components differ?
- Fringe field effects may make difference (my understanding)
2. Current status

➤ **Lattice translation: SAD to MAD-X**
  - A translator written in SAD script is available, and used to publish FCC-ee lattices. To be extended (K. Oide)
  - MULT element with Kn (n=1,2,...) superimposed by solenoid field is the most difficult (A. Morita). Not successful in the case of KEKB/SuperKEKB
  - Without solenoid field: mostly straightforward. Succeeded in FCC-ee (K. Oide)

➤ **SAD manual is under preparation**
  - Not easy but should be available in 2017
  - Requests from users are always welcome
3. SuperKEKB lattice translation

➤ Normal components

- If \( L=0 \), \( K_n(SAD)=K_n(MAD-X) \)
- If \( L\neq0 \), \( K_n(SAD)=K_n(MAD-X)*L \)

➤ DRIFT

- SAD uses exact Hamiltonian/transformation for tracking
- MAD-X uses second-order map (?)
- Need extra MATRIX element for better approximation when the angle of the closed orbit is large. For large amplitude particles, this still has limitations

➤ BEND element

- BEND with ANGLE\(\neq0 \) defines layout, equivalent to RBEND or SBEND in MAD-X
- BEND with ANGLE\(=0 \) but \( K_0\neq0 \) works as a kicker or steering magnet. Hybrid component with \( K_0\neq0 \) and \( K_n\neq0(n\geq1) \) need special treatment
3. SuperKEKB lattice translation

➤ Fringe fields
  • Hard- (or Maxwellian fringe field) and soft-edge fringes (induce linear and nonlinear effects) are important in SuperKEKB
  • Treatments of MAD-X are different from SAD
  • PTC in MAD-X is similar to SAD but has tiny differences.

➤ SOL element
  • Tilted with crossing angle
  • Fringe fields
  • Reference trajectory is aligned with the solenoid axis to simplify the transformation

➤ SAD MULT element
  • Very general type: include field components of solenoid, multipole ($K_0$ to $K_{21}$, $SK_0$ to $SK_{21}$), fringes, and even RF fields.
  • No equivalent element in MAD-X
  • Very important in SuperKEKB (superimposed fields of detector solenoids, FF quads and others)
3. SuperKEKB lattice translation

➤ Shift in longitudinal z coordinate of a particle
  ● Automatically done in SAD to counteract a difference between the length of the reference orbit and the closed orbit
  ● Likely no similar treatment in MAD-X (?)

➤ For phase-3 lattice (w/ IR)
  ● D. Sagan tried SAD => Bmad => MAD-X
  ● Use MAD-X MATRIX element (contains nonlinear map in second order of phase space coordinates?) to approximate fringes and SAD MULT components
    ● Need PTC integrated into Bmad to construct the MAD-X MATRIX element

➤ For phase-1 lattice (w/o IR)
  ● S.M. Liuzzo(ESRF) tried SAD => AT => MAD-X
  ● Almost OK except treatment of quad soft-edge fields
  ● Direct SAD => MAD-X is possible (not tried yet)
3. SuperKEKB lattice translation

➤ MAD-X model of phase-1 lattice (w/o IR)

- Close to SAD
- Expected better agreement if quad soft-edge fringes included

Courtesy of S.M. Liuzzo
3. SuperKEKB lattice translation

➤ MAD-X model of phase-3 lattice (w/ IR)
  ● Close to Bmad (≈SAD) as a beam line (not a ring)
  ● Not good for a ring to do optics tuning and advanced studies

Courtesy of D. Sagan and M. Biagini
4. Summary

➤ MAD-X <-> SAD lattice translation

- Multi-purpose: to support collaborations between labs (KEK, CERN, INFN, IHEP, etc.) on different projects (SuperKEKB, FCC-ee, CEPC, LHC, etc.)
  - Undergoing smoothly
  - Welcome requests and collaborators (Great for PhD candidates and postdocs to improve future communications)
  - Need help from MAD-X experts for special elements (fringes, solenoid, etc.)

➤ SuperKEKB lattice translation

- Looks good w/o solenoid (except quad soft-edge fringes)
- Not satisfying w/ solenoid