Summary Session: Lattice Solutions towards High Brightness

Yoshiteru Hidaka
3 Talks

Lattice Solutions towards High Brightness
08:30  **Review of Lattice Options for High-Brightness Light Sources** 25’
Speaker: Laurent Nadolski

08:55  **Comparison of Optimization Methods for APS Upgrade Nonlinear Dynamics** 25’
Speaker: Yipeng Sun

09:20  **Coupling Control and Optimization at Diffraction-Limited Light Sources** 25’
Speaker: Christoph Steier
Review of Lattice Options for High-Brightness Light Sources (L. S. Nadolski, SOLEIL)

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<tr>
<th>Chain</th>
<th>Energy</th>
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<th>Emittance</th>
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<th>Lattice</th>
<th>Qx</th>
<th>Qy</th>
<th>Q’x</th>
<th>Q’y</th>
<th>Optics strain</th>
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**Optics strain = Qx’/Qx * Qy’/Qy**

- **Compact & Rigid** lattice
- **Exotic** magnets
- **TGB / LGB**
- **Combined function** - magnets

**Hybrid MBA** more adapted for large storage ring (sextupole strength relaxed)

Relevant cell length is the one limited to magnetic structure

**Anti-bend** relaxes fairly nicely the constraints on the emittance and increases tunability

**High periodicity** is privileged for ultra-low emittance lattices

3-4 % LMA

Low MCF
Deciding on the “M” part of the MBA.

MAX-IV style (or ‘traditional’) 7BA*

\[ \varepsilon_0 \sim \frac{\gamma^2}{N^3_B} \]

SIRIUS  MAX-IV
ELETTRA-II*  SLS-II**
ALS-U***  CLS-II
SLiT-J
ESRF-EBS  HEPS
PEPX  APS-U*
SPRing8-II  PETRA-IV
DIAMOND-II***  SOLEIL-II***

* variation
Comparison of Optimization Methods for APS Upgrade Nonlinear Dynamics (Y. Sun, ANL)

- Both linear and nonlinear optics optimized for APS-U 41-pm lattice
- Different algorithms and optimization targets implemented for nonlinear optics optimizations
  - Some are much faster than original optimization approach using LMA
  - Explored different solutions spaces
  - Comparable performance
- There are some indications that improved orbit and lattice correction will allow increasing the lifetime of APS-U
- APS applications improved machine performance
  - Simulation based optimization
  - Online machine based optimization
In general, these methods take less computing time than LMA and DA

- **ANA**: objective of nonlinear chromaticity and driving/detuning terms\(^1\)
  - Objectives targets selected from optimization results of other methods (LMA, DET...)

- **CSI**: objective of CS invariant distortion and chromatic detuning\(^2,3,4\)
  - Track for one turn, or one super-cell
  - Different initial conditions of x-y space

- **DET**: objective of detuning of x-y grids, w/ or w/o energy offset

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Coupling Control and Optimization in DLSRs
(C. Steier, LBNL)

• Coupling correction is important to optimize the performance
  – Direct benefit: increased brightness
  – Also improves dynamic (momentum) aperture and therefore injection efficiency and lifetime

• There are several correction methods:
  – Combined approach targeting local coupling, global coupling and vertical dispersion simultaneously is usually used.
  – Using orbit response matrix analysis (LOCO), emittance ratios below 0.1% have been achieved (<1 pm at ALS).

• DLSRs can require larger emittance ratios than currently in use
  – Multiple ways to achieve (including operating on coupling resonance)
  – Beam dynamics impact manageable
  – Beamsize stability requires good tune control, reasonable resonance strength

• Insertion devices provide new challenge if they contribute significantly to total energy loss
Emittance Stability and Undulators

Max-4 example: S. Leemann, et al., PRSTAB 12, 120701 (2009)

- DLSRs / MBAs / Rings with low average bend magnet field have Beamsize stability issue beyond coupling
- Significant variation of energy loss per turn results in variation of damping times, natural emittance, energy spread
- Extend of effect varies, but can be >20% (including machines already in operation)
- This does not just mean emittance goes down as more undulators are installed, also depends on undulator scans (larger field variation for longer period undulators – ALS: undulator energy loss varies 50% typical week)
- (Additional) Damping wigglers can help in correction, but expensive (cost, space, RF) – full range might not be feasible
  - Other means are less efficient (e.g. limited tunability of MBA lattices)
  - Need to better understand user requirements / impact of uncorrected or partially mitigated