Study of Seven-Bend-Achromat Lattice Option for HALF

Jianhao Xu[1], Zhiliang Ren[1], Jiajie Tan[1], Penghui Yang[†,1], Zhenghe Bai[*,1] ,Qingkun Zhang[2]
[1]National Synchrotron Radiation Laboratory, USTC, Hefei 230029, China
[2]Institute of Nuclear Energy Safety Technology, Chinese Academy of Science, Hefei 230031, China

Abstract A new seven-bend-achromat (7BA) storage ring lattice design for Hefei Advanced Light Facility (HALF) with a beam energy of 2.2 GeV and a circumference of 388.8 m is presented. The 7BA lattice is designed with the combined function bends and reverse bends which has a natural emittance of about 67 pm·rad. Two lattice candidates with different tunes have been selected. One lattice has better nonlinear dynamic performance for off-axis injection. The other lattice provides lower beta functions at the center of straight sections.

Introduction

The type of lattice is preliminarily designed as a possible option for the HALF. The designed diffraction-limited storage ring composed of 20 identical cells, has an energy of 2.2 GeV, and a circumference of 388.8 m. All bends are combined function bends with transverse gradient. At the same time, for reducing the emittance further, two quadrupoles in the high-dispersion region and the central region were converted into reverse bending magnets.

7BA Lattice Design

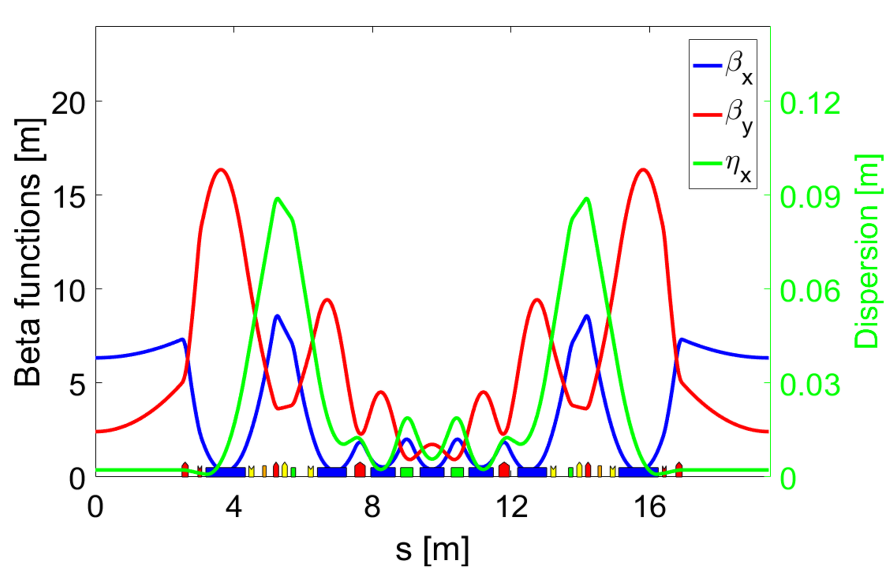
- -I transformation: introduce two sextupole families, the phase advances between them are $(3\pi, \pi)$.
- higher-order achromat: the tunes in one lattice cell are set to (2.4, 0.9) or (2.6, 0.9) to ensure that a number of nonlinear terms can be eliminated in five lattice cells.

Case 1: off-axis injection lattice

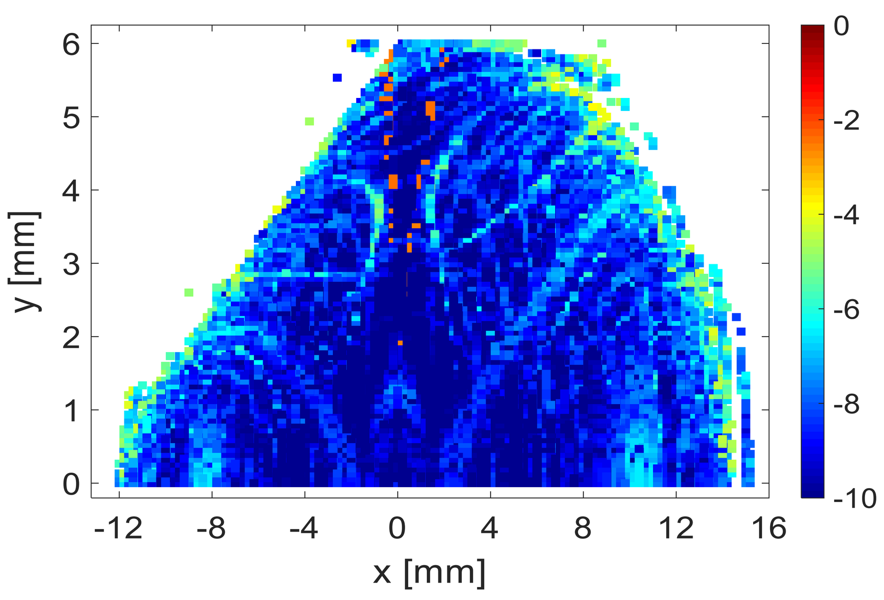
The first lattice was optimized for off-axis injection. The lattice was firstly optimized to have small emittance and the sum of the integral strengths of three families of sextupoles. Then the nonlinear dynamic performance of the lattice was further optimized using three families of sextupoles and one family of octupole.

✓Fig. 1: Linear optical functions and magnet layout of one selected lattice solution .
✓Fig. 2: Frequency map analysis of the optimized DA. Top: *x-y* space. Bottom: tune space. The horizontal DA is about 12 mm and there is no dangerous resonance inside the DA.
✓Fig. 3: Momentum dependent tune footprints. The horizontal tune crosses the half-integer resonance line at the momentum deviation of about -3.4%.

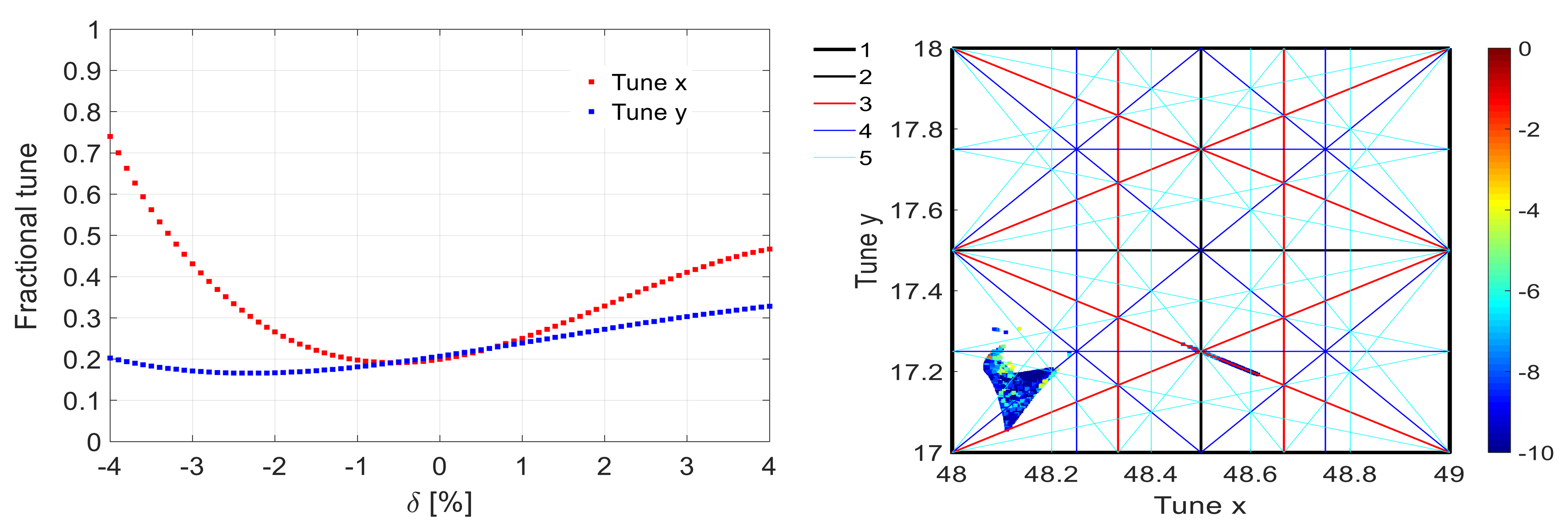
1



2



3

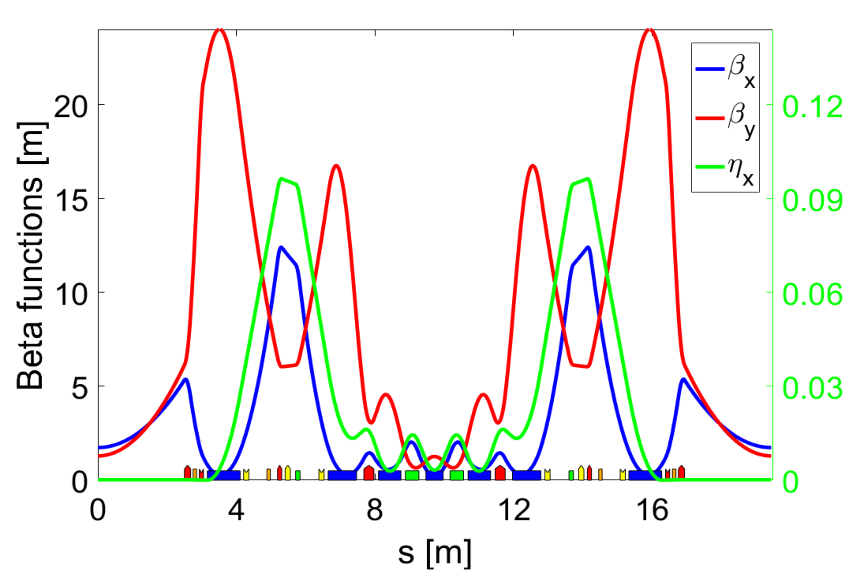


Case 2: low beta lattice

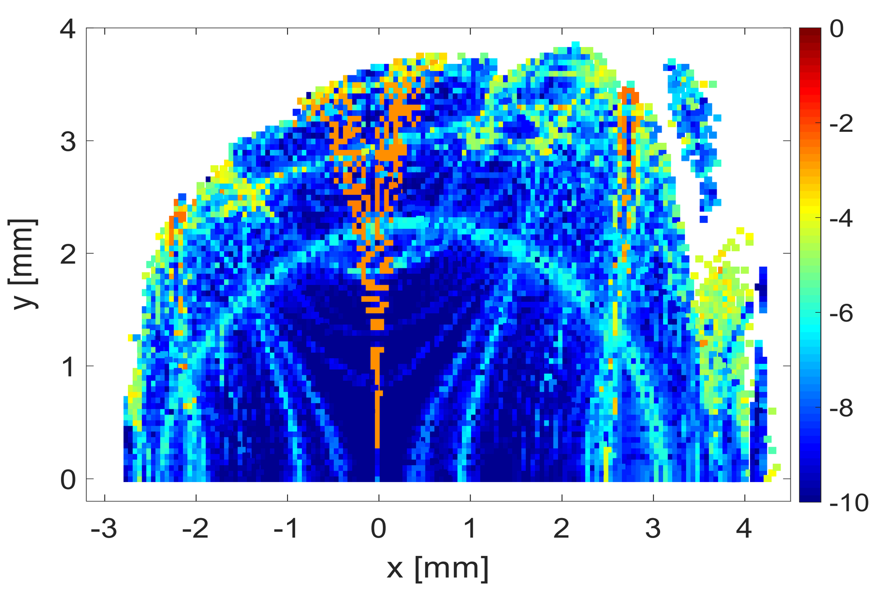
The second lattice was optimized with lower beta functions at the center of straight sections. Compared with *case 1*, the strengths of the magnets are increased due to the increase of the tunes. Three families of sextupoles and two families of octupoles were used to optimize the nonlinear dynamic performance.

✓Fig. 1: Linear optical functions and magnet layout of one selected lattice solution .
✓Fig. 2: Frequency map analysis of the optimized DA. Top: *x-y* space. Bottom: tune space.
✓Fig. 3: Momentum dependent tune footprints.

1



2



3

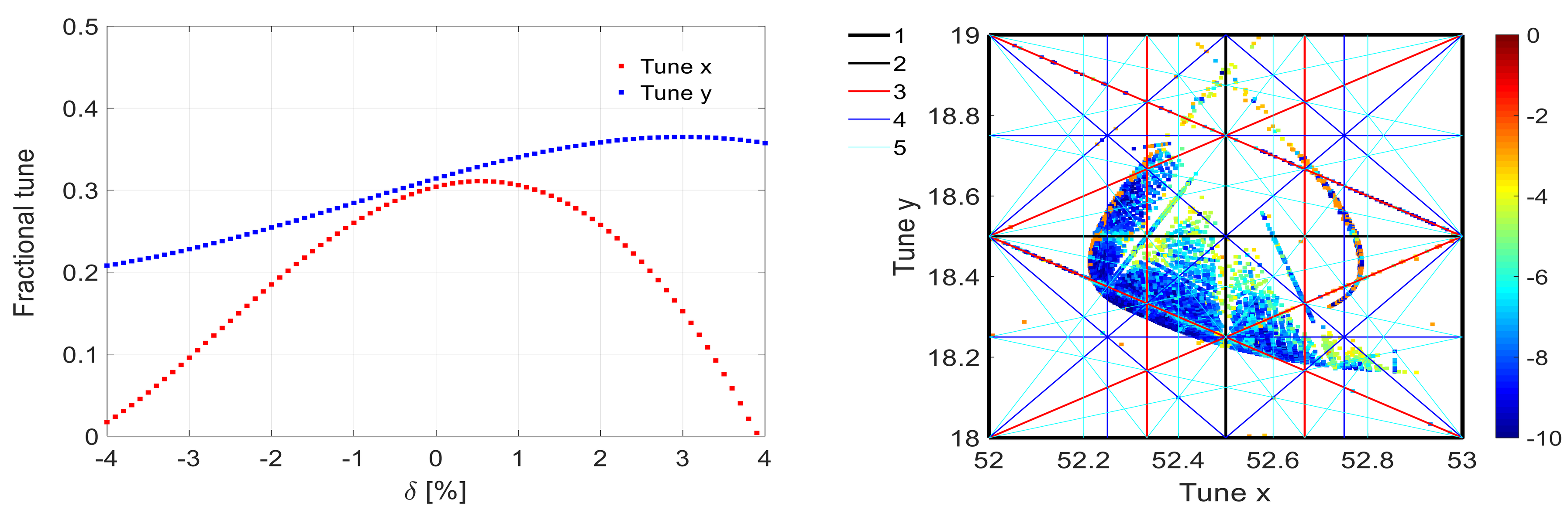


Table 1: Main parameters of two storage ring designs for case 1 and case 2.

Parameters	Case 1	Case 2
Beam energy (GeV)	2.2	
Circumference (m)	388.8	
Cell number	20	
Length of straight sections (m)	5	
Nat. emittance (pm rad)	67.1	67.4
Betatron tunes (H/V)	48.20/17.21	52.31/18.32
Nat. chromaticities (H/V)	-73.6/-58.4	-89.1/-89.1
Momentum compaction factor	1.21E-04	1.15E-04
Beta functions at straight sections (H/V) (m)	6.34/2.32	1.62/1.42
Radiation loss per turn (keV)	156.0	170.2
Damping times (ms)	16/37/46	15/34/42

Conclusion

A 7BA lattice has been designed with the combined function bends and reverse bends. The lattice with small tunes has better nonlinear dynamic performance compared to the lattice with large tunes. But the other with large tunes has lower beta functions at the center of straight sections, which means higher brightness can be achieved.