Multiple bunch length operation mode design at HLS-II storage ring

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Abstract

In this paper we design a simultaneous three bunch length operating mode at the HLS-II (Hefei Light Source II) storage ring by installing two harmonic cavities and minimizing the momentum compaction factor. The short bunches (2.6 mm) presented in this work will meet the requirement of coherent THz radiation experiments, and the long bunches (20 mm) will efficiently increase the total beam current. Therefore, this multiple-bunch-length operating mode allows present synchrotron users and THz users to carry out their experiments simultaneously. Also we analyzed the physical properties such as the CSR effect, RF jitter and Touschek lifetime of this operating mode.

Introduction

Simultaneous three kinds of bunch length operation at HLS-II storage ring is discussed. The momentum compaction factor is minimized firstly. And then two harmonic cavities are installed at the low alpha lattice. Combining the two method , the origin 45 bunches are filled with three kinds of bunch lengths. The novelty of our work is that we get a multiple bunch length operational mode without multi cell superconducting cavities. So that the HOM problem can be avoided, and this is technically feasible.

low alpha lattice design

The main twiss parameters of this new low alpha lattice are shown in Table 1.

Table 1: Twiss parameters of the low alpha lattice

Emittance	87nm-rad
Tunes	5.72/2.58
Natural chromaticity	-20.29/-15.95
Momentum compaction factor	0.0039

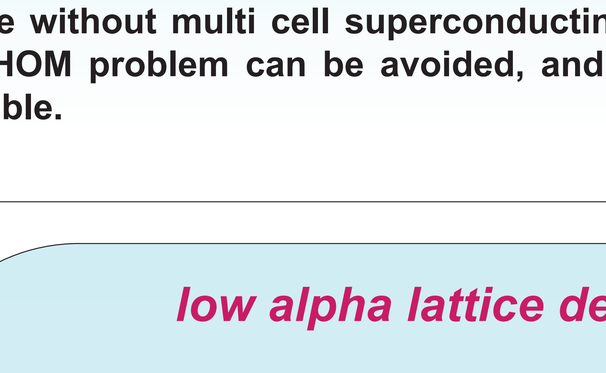

Figure 1:
Twiss functions
of the low alpha lattice.

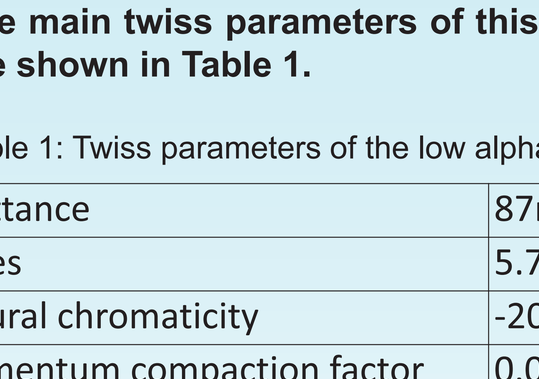

Figure 2: Dynamic aperture of the low alpha lattice, 4000 particles tracked with 1000 turns.

multiple-bunch-length operation design at the low alpha lattice by harmonic cavities

The three cavity's parameters are listed in Table 2.

Cavity	Basic RF	Harmonic RF-I	Harmonic RF-II
Voltage	250kV	186kV	184kV
phase	176.17deg	-79.0338deg	81.2895deg
Frequency	204MHz	747.9864MHz	679.9932MHz
Harmonic number	45	165	150

The sum voltages of the three RF cavities as a function of the longitudinal position are shown in Fig. 3.

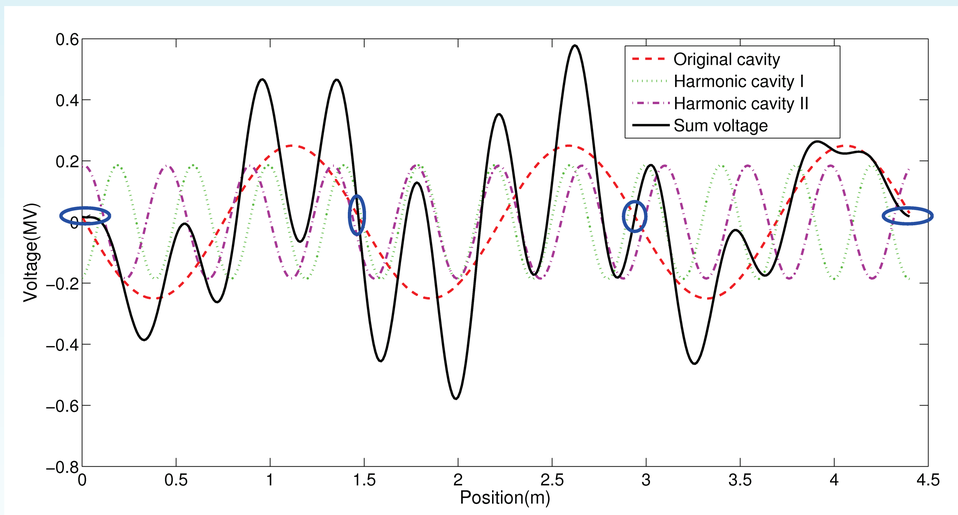

Figure 3: Accelerating voltage vs. position.

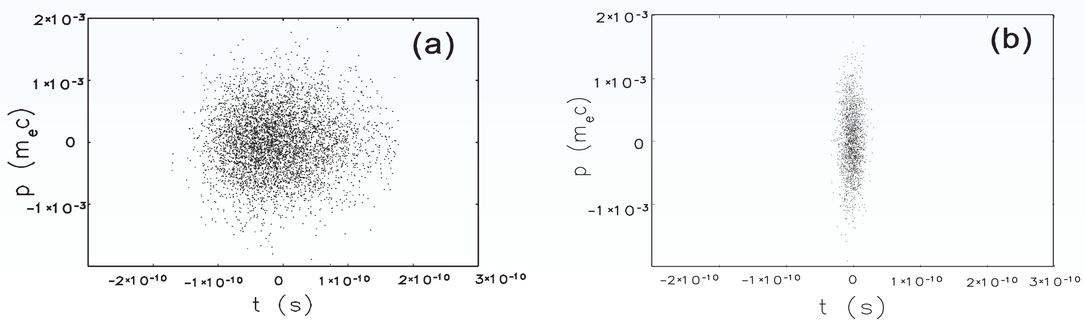

Figure 4: Tracking longitudinal phase space; plot (a) is the phase space of the long bunch (66 ps) and plot (b) is that of short bunch (8.7 ps).

CSR instability analysis

The result shows that the single beam current threshold of the long bunch is 8.6 mA.

$$I_{th} > \frac{3\sqrt{2}\alpha\gamma\sigma_\delta^2 I_A \sigma_z}{\pi^{3/2} h}$$

we find that the CSR microwave instability threshold of the short and medium beams is 1.62 mA, and 1.82 mA, respectively.

$$I_{th} > \frac{4\pi\xi^{th}(\chi)\sigma_z^{7/3} f_0}{c^2 Z_0 \rho^{1/3}} \sum \frac{\partial V_{rf}}{\partial z}.$$

Conclusions

The old RF cavity of HLS-II was used and the newly added two harmonic cavities' harmonic numbers are the 11/3-th harmonic and the 10/3-th harmonic of the original RF cavity. After installing two harmonic cavities at the low alpha lattice, we achieve three kinds of bunch lengths. The short bunch can radiate at the coherent THz range and the long bunch can increase the total beam current for normal users.

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