A Lattice for the Future Project of VUV and Soft X-Ray High Brilliant Light Source

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I. Introduction

Presented in this paper is a lattice for a third-generation VUV and soft X-ray light source1, which is a future project of the Institute for Solid State Physics (ISSP) of the University of Tokyo and is being designed in close collaboration with the Photon Factory of KEK. The storage ring has an energy of 2 GeV, a circumference of about 400 m, an emittance of less than 5 nm rad, four 13 m long straight sections and twelve 7 m semi-long straight sections. We first present the lattice design of the ring, the chromaticity correction and the dynamic aperture, and next present a new lattice which is now under study to improve the performance.

II. Lattice Design

Table 1 shows the fundamental parameters of the ring, which has a circumference of 374.14 m and an emittance of 4.88 nm. The ring consists of 16 DBA cells. Each cell has two straight half-sections for insertion devices at both ends. The number of the straight sections are 16. Four of them are 13 m long and twelve of them are 7 m long. The 13 m long straight sections are arranged with a four-fold symmetry. A cell with 7 m semi-long straight half-section is called Normal Cell and a cell with 13 m long straight half-section at one end is called Long Cell (see Table 2). The lattice configuration of a Long Cell is the same as that of a Normal Cell except for three quadrupole magnets (Q1L, Q2L, Q3L), which is used for matching of the betatron functions in the 13 m long straight section. Figure 1 shows the betatron and dispersion functions for an octant of the ring. We have used SAD2 code for the lattice calculation.
IV. Chromaticity Correction and Dynamic Aperture

The horizontal chromaticity of the ring is -49.98 and the vertical one is -17.75. The chromaticities have been corrected by using chromatic sextupoles (SF0, SD0) located in the dispersive region of the cell. The strengths of these sextupoles are $B'' = 498 \, [T/m^2]$ for SF0 and $B'' = -392 \, [T/m^2]$ for SD0. These sextupoles, however, introduce nonlinear effects which limit the dynamic aperture. In order to obtain a dynamic aperture as large as possible, the harmonic sextupoles (SF1, SD1, SF1L, SD1L) have been incorporated in the dispersionless region of the lattice. The horizontal dynamic aperture must be larger than the half width of the vacuum chamber (40 mm) at the position where the horizontal betatron function is maximum, while the vertical dynamic aperture must be larger than the half height of the vacuum chamber (10 mm) for an insertion device. A wide momentum aperture ($\pm 3\%$) is also required to obtain a long Touschek lifetime. By optimizing the harmonic sextupoles, we have obtained a sufficiently large dynamic aperture as shown in Fig. 2. Here the dynamic aperture is defined as the stable region in which a particle can revolve the ring over 1000 turns.

V. New Lattice

We are making some modification to the lattice described above to improve the following points:

1) quadruple magnets should not be C-type,
2) the access to the BPM should be easier.

For (1), Q3 and Q3L have been shifted away from bending magnets not to touch the beamlines for the synchrotron radiation (see Table 2). For (2), every drift space between a

<table>
<thead>
<tr>
<th>Element</th>
<th>L [m]</th>
<th>Element</th>
<th>L [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>3.5</td>
<td>*3</td>
<td>6.62</td>
</tr>
<tr>
<td>Q1</td>
<td>0.4</td>
<td>Q1L</td>
<td>0.4</td>
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<tr>
<td>Q2</td>
<td>0.6</td>
<td>Q2L</td>
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<tr>
<td>Q3</td>
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<td>Q3L</td>
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</tr>
<tr>
<td>B</td>
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<td>B</td>
<td>1.3</td>
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<tr>
<td>Q4</td>
<td>0.4</td>
<td>Q4</td>
<td>0.4</td>
</tr>
<tr>
<td>SF0</td>
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<td>SF0</td>
<td>0.2</td>
</tr>
<tr>
<td>SD0</td>
<td>0.2</td>
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<td>0.2</td>
</tr>
<tr>
<td>*2</td>
<td>-</td>
<td>*4</td>
<td>-</td>
</tr>
<tr>
<td>*3</td>
<td>6.62</td>
<td>*5</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2: The lattice of the Normal Cell and Long Cell. The element lengths of the new lattice different from those of the old one are listed in the table. *1 is the symmetric point of 7 m insertion section, *2 the mirror symmetric point of the normal cell, *3 the symmetric point of 12.5 m insertion section, *4 the point where the long cell is connected to the mirror symmetric point of the normal cell.
quadrupole magnet and a sextupole magnet has been lengthened from 0.15 m to 0.2 m.

In order to keep of the betatron functions of 7 m semi-long straight sections to almost the same values as in the old lattice and to obtain a flexibility of optics for long straight sections, the polarities of the quadrupole magnets (Q1, Q2, Q3) have been changed. Since this change causes the magnetic field of Q3 to be saturated, the lengths of Q3 is increased from 0.4 m to 0.6 m.

With these modifications, the circumference of the ring has become from 374.14 m to 388.45 m, the harmonic number from 624 to 648. However long straight sections have become a little bit shorter; from 13 m to 12.5 m for long straight sections and from 7 m to 6.6 m for semi-long straight sections. The new parameters of the ring are listed in Table 3. The betatron and dispersion functions for an octant of the new ring are shown in Fig. 3.

The dynamic aperture for this lattice is now under study. So far, the horizontal dynamic aperture is 30 mm at the maximum position of horizontal betatron function, while the vertical dynamic aperture is 13 mm at the center of the insertion device. It is expected that the dynamic aperture is further improved.

### VI. REFERENCES


[2] SAD is developed by KEK accelerator group.

<table>
<thead>
<tr>
<th>Table 3: New parameters of the storage ring.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy E [GeV]</td>
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<td>Lattice type</td>
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<tr>
<td>Superperiod</td>
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<tr>
<td>Circumference C [m]</td>
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<tr>
<td>semi-long straight section</td>
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<tr>
<td>long straight section</td>
</tr>
<tr>
<td>Natural emittance εx0 [nm rad]</td>
</tr>
<tr>
<td>Energy spread σE/E</td>
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<tr>
<td>Momentum compaction α</td>
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<tr>
<td>Horizontal tune νx</td>
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<tr>
<td>Vertical tune νy</td>
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<tr>
<td>Horizontal natural chromaticity δx</td>
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<tr>
<td>Vertical natural chromaticity δy</td>
</tr>
<tr>
<td>Horizontal damping time τx [msec]</td>
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<tr>
<td>Vertical damping time τy [msec]</td>
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<tr>
<td>Longitudinal damping time τe [msec]</td>
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<td>Revolution frequency f_Rev[MHz]</td>
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<tr>
<td>RF voltage V_RF [MV]</td>
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<tr>
<td>RF frequency f_RF [MHz]</td>
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<tr>
<td>Harmonic number h</td>
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<tr>
<td>Synchrotron tune νs</td>
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<tr>
<td>Bunch length σz [mm]</td>
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<tr>
<td>RF-bucket height (ΔE/E)</td>
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</tbody>
</table>

Fig. 3: New optics for an octant of the ring