Analysis of field data of the wigglers in SuperKEKB LER

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Acknowledgements:
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Outline

➤ Background
  ● There is larger discrepancy between measured and modelled chromaticity in SuperKEKB LER than in HER. The main difference is that there is wiggler section in LER but not in HER in phase-1 commissioning.

➤ Idea
  ● SAD modelled wiggler with parameters K0, L, F1 (or FB1 and FB2)
    ● The wiggler parameters used in SAD lattice should be double checked

➤ Summary
1. Field data for wigglers in LER

➤ Measured field data from K. Egawa

● There is interference between wiggler poles

Magnetic Field Coupling Measurement: LER wiggler system

 Courtesy of K. Egawa
1. Field data for wigglers in LER

- Measured field data from K. Egawa
  - There is interference between wiggler poles

B[z] : WS (J=1150.96A) & kbwigg (J=1106.5A)  

B[z] : WH (J=970A) & kbwigg (J=1106.5A)  

Courtesy of K. Egawa
2. SAD model for wigglers in LER

- **sler_1701_phase1.sad**
  - Assumed symmetric fringes: likely not good
  - Calculated tune \(nx=44.53, ny=46.57\)

<table>
<thead>
<tr>
<th>BW0NRPM</th>
<th>L = 0.215946</th>
<th>ANGLE = 0</th>
<th>E2 = 1</th>
<th>K0 = -0.0107248</th>
<th>F1 = 0.1138</th>
<th>FRINGE = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW1NRPM</td>
<td>L = 0.334831</td>
<td>ANGLE = 0</td>
<td>E1 = 0.5</td>
<td>E2 = 0.5</td>
<td>K0 = -0.0219048</td>
<td>F1 = 0.1138</td>
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<tr>
<td>BW2NRPM</td>
<td>L = 0.338537</td>
<td>ANGLE = 0</td>
<td>E1 = 0.5</td>
<td>E2 = 0.5</td>
<td>K0 = 0.02236</td>
<td>F1 = 0.1138</td>
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<tr>
<td>BW3NRPM</td>
<td>L = 0.332919</td>
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<td>E1 = 0.5</td>
<td>E2 = 0.5</td>
<td>K0 = -0.02236</td>
<td>F1 = 0.1138</td>
</tr>
</tbody>
</table>
1. Field data for wigglers in LER

➤ Measured field data from K. Egawa

• There is interference between wiggler poles

![Graph showing field data for wigglers in LER with annotations for half pole, kekB wiggler, single pole, kekB wiggler, and half pole.]

\[ B[z] : WS (J=1150.96A) & \text{kbwigg} (J=106.5A) \]

\[ B[w] : WH (J=570A) & \text{kbwigg} (J=1106.5A) \]

\[ \delta = 0.02036 \]

Length of the slope of the field at the edge as:

\[ By(s) | \] ★★★★★★
| * 
| * 
| * 
| * 
| * 
| * 
| * 

Only the effects up to y^4 in Hamiltonian are taken into account. More rigorous definition is:

\[ F_1 = 6 \int \frac{By(s)}{B_0} (By(s)/B_0)^2, \{s, -\text{Inf}, \text{Inf}\} \]

where integration is done over one fringe.

Courtesy of K. Egawa
2. SAD model for wigglers in LER

- sler_1701_phase1.sad with new fringe lengths
  - Recalculation shows significant difference (mainly in fringe lengths) from the present model.
  - For K0, I used the original data.
  - Calculated tune nx=44.53, ny=46.535
  - Small change in chromaticity. But after optics correction (to recover beta function), chromaticity might change.

<table>
<thead>
<tr>
<th>BW0NR</th>
<th>(L = .215931)</th>
<th>ANGLE =0</th>
<th>E2 =1</th>
<th>K0 = .0107248</th>
<th>FB1 = .2039</th>
<th>FB2 = .1471</th>
<th>FRINGE =1</th>
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</thead>
<tbody>
<tr>
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<td>(L = .334854)</td>
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<td>E1 =.5</td>
<td>E2 = .5</td>
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<td>FB1 = .1705</td>
<td>FB2 = .1537</td>
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<tr>
<td>BW2NR</td>
<td>(L = .338559)</td>
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<td>K0 = .02236</td>
<td>FB1 = .1536</td>
<td>FB2 = .1865</td>
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<td>BW3NR</td>
<td>(L = .333550)</td>
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<td>F1 = .1856</td>
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<tr>
<td>BW0NRMP</td>
<td>(L = .215931)</td>
<td>ANGLE =0</td>
<td>E2 =1</td>
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<td>F1 = .1856</td>
<td>FRINGE =1</td>
</tr>
</tbody>
</table>
2. SAD model for wigglers in LER

➤ Alternative fringe model

● Use fringe field integrals

\[
\begin{align*}
I_0^- &= \int_{s_1}^{s_0} \tilde{K}(s) ds \\
I_1^- &= \int_{s_1}^{s_0} \tilde{K}(s)(s-s_0) ds \\
I_2^- &= \int_{s_1}^{s_0} \tilde{K}(s)(s-s_0)^2 ds \\
I_3^- &= \int_{s_1}^{s_0} \tilde{K}(s)(s-s_0)^3 ds \\
I_0^+ &= \int_{s_0}^{s_2} \tilde{K}(s) ds \\
I_1^+ &= \int_{s_0}^{s_2} \tilde{K}(s)(s-s_0) ds \\
I_2^+ &= \int_{s_0}^{s_2} \tilde{K}(s)(s-s_0)^2 ds \\
I_3^+ &= \int_{s_0}^{s_2} \tilde{K}(s)(s-s_0)^3 ds
\end{align*}
\]

SuperKEKB mini optics meeting, Jun.18, 2015
D. Zhou, IPAC’10
## 2. SAD model for wigglers in LER

➤ Compare different models

### Fringe length

<table>
<thead>
<tr>
<th>Pole</th>
<th>BW0NRP</th>
<th>BW1NRP</th>
<th>BW2NRP</th>
<th>BW3NRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fringe length</td>
<td>FB1</td>
<td>FB2</td>
<td>FB1</td>
<td>FB2</td>
</tr>
<tr>
<td>Old model</td>
<td>0.1138</td>
<td>0.1138</td>
<td>0.1138</td>
<td>0.1138</td>
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<tr>
<td>SAD method</td>
<td>0.2039</td>
<td>0.1471</td>
<td>0.1705</td>
<td>0.1537</td>
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<td>D.Z method</td>
<td>0.2225</td>
<td>0.1481</td>
<td>0.1725</td>
<td>0.1552</td>
</tr>
</tbody>
</table>
3. Summary

➢ Findings
  ● Fringe lengths for wiggler in SuperKEKB LER might not be good enough.

➢ Discussion
  ● Why FRINGE=1? How about FRINGE=3?