Homework 12

April 10, 2020

Problem 1. (40 pts)

Let us calculate the longitudinal dynamics and synchrotron radiation related problem in NSLS II. NSLS II adopts DBA lattice (illustrated in Figure 1).

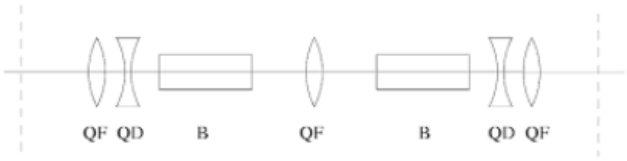

Figure 1: DBA lattice

Here are the parameters:

Table 1: NSLS II parameters

Parameters	Values
Energy [GeV]	3.0
Circumference [m]	780
Number of dipoles	60
Dipole field [T]	0.4
Beam current [A]	0.5
RF frequency [MHz]	499.68
Harmonic number	1320

From the design parameters, we can calculated the following parameters:

- Find the length of the dipoles assuming all dipoles are the same.
- In DBA lattice, dispersion D and dispersion slope D' are zero at one end of dipoles and non-zero at the other end of the dipole. Find dispersion function inside the dipole magnet.
- What is the compaction factor α_c of the ring?

- The energy loss due to the dipole field.
- If the accelerating phase of the RF cavity is $\pi/6$, at least how much voltage is required? How much is the power needed?
- Actually the RF voltage is about 3MV. Find the longitudinal tune of NSLS II
- What is the critical radiation frequency of the dipole radiation.
- Find the partition number $\bar{D}$ due to synchrotron radiation in dipole.
- Find the longitudinal damping rate α_E and compare with the period of longitudinal oscillation.
- Find the equilibrium energy spread of NSLS II.

Problem 2. (10 pts)

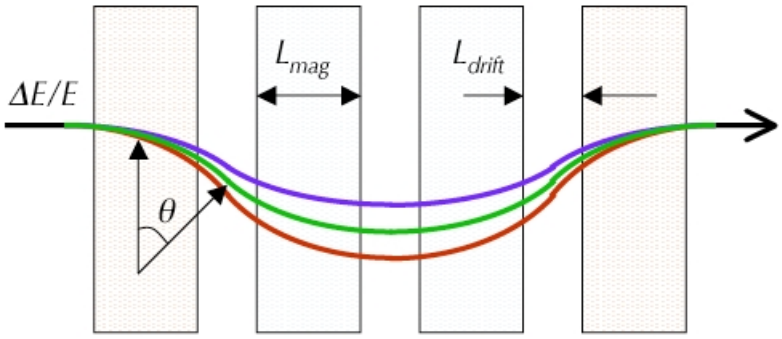

Figure 2: Layout of Chicane

A chicane usually consist of 4 identical dipoles as shown above. Each dipole has length of L_B and bend the beam angle θ_B. The drift space between two adjacent dipole is L_1. Please prove that:

$$R_{56} = \frac{dz}{d\delta} \sim 2\theta_B^2 \left(L_1 + \frac{2}{3} L_B \right)$$

Problem 3. (20 pts)

Consider the parameter of LCLS:

Please find:

Table 2: Parameter of LCLS

Parameters	Values
Beam energy	14.35 GeV
Peak current	3500 A
Pulse length	230 fs
FEL parameter	5×10^{-4}
RMS angular divergence	1.7 μrad
Undulator wavelength	3 cm
Undulator parameter K	3.7

1. Radiation wavelength λ_r
2. Bunch charge of each electron bunch.
3. Approximate number of electrons that in one 'micro-bunch'
4. 1-D gain length L_{1D}
5. Approximated undulator length
6. Approximated peak radiation power
7. The width of the frequency spectrum at saturation.