

Introduction to Particle Accelerator Physics

Tutorial 3 - Problems

Discussion: 6.12.2005

Hand in: 13.12.2005

Solutions: 17.1.2006

1. Dispersion Function

An often heard statement is "dispersion is generated in bends". Comment on this statement by examining the dispersion function $D(s)$ in straights, i.e. in the limit $\rho \rightarrow \infty$.

2. Momentum Compaction Factor

In the SLS storage ring the (linear) momentum compaction factor is $\alpha_c = 6.3 \cdot 10^{-4}$. The maximum momentum spread is 0.09%. Keeping in mind the revolution frequency $f = 1.04167$ MHz, calculate the maximum absolute change in path length.

3. Stability Criterion for a Circular Accelerator

Recall from the lecture the generalized one-turn transformation matrix M_{Rev} .

- Without loss of generality we can choose a starting point in the accelerator where $\alpha_0 = -\frac{\beta'_0}{2} = 0$. What does the matrix look like now?
- Recall the betatron tune defined as $Q = \frac{\mu}{2\pi}$. Think about the relationship between this matrix and phase space. What does μ represent? What does Q represent?
- Calculate the trace of this matrix. Considering that the cos function has a co-domain of $[-1, +1]$ in \mathbb{R} , can you derive a simple stability criterion for M_{Rev} ?

4. Phase Space Representations of Particle Sources

- Consider a source at s_0 with radius w emitting particles. Make a drawing of this setup in configuration space and in phase space. Which part of phase space can be occupied by the emitted particles?
- Any real beam emerging from a source like the one above will be clipped by aperture limitations of the vacuum chamber. We can model this by assuming that a distance d away from the source there is an iris with an opening with radius $R = w$. Make a drawing of this setup in configuration and phase space. Show which parts of phase space are occupied by the beam at a location after the iris.

5. Decapolar Magnetic Field

Using the technique presented in the lecture, derive the magnetic induction and equipotential lines for a magnetic field with decapolar component in the horizontal plane (in absence of charges and/or currents).