Prof. Dr. Albin F. Wrulich EPFL, WS 2004/2005

Introduction to Particle Accelerator Physics

Exercise 4

Discussion: 14.12.2004 Hand in: 21.12.2004 Solutions: 4.1.2005

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1. Phase Space Representations of Particle Sources
a) 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?
b) 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.

2. Quadrupole Errors and Tune Shifts
In the lecture a quadrupole focussing error was introduced into Hill's equation by replacing the focussing function $K(s)$ with $K(s) + \Delta k(s)$. It was then proposed that the error in the focussing function could be represented as a gradient error $\Delta(kl)$ leading to a tune shift $\Delta Q = \frac{1}{4\pi}\beta_0\Delta(kl)$. Assume that the tune shift is small with respect to the tune and prove this statement.

3. Momentum Compaction and Transition Energy
Dispersion leads to path length changes for off-momentum particles. This is characterized by the momentum compaction factor α_c defined in the lecture. Considering that timing is very important in an accelerator, can path length changes be related to a change of the revolution period? Or in mathematical terms, how does $\frac{\Delta T}{T}$ depend on $\frac{\Delta p}{p}$? Is it possible to build an accelerator where $\Delta T = 0$ regardless of Δp ?

Assistant: Simon C. Leemann, simon.leemann@psi.ch, 056/310 3343