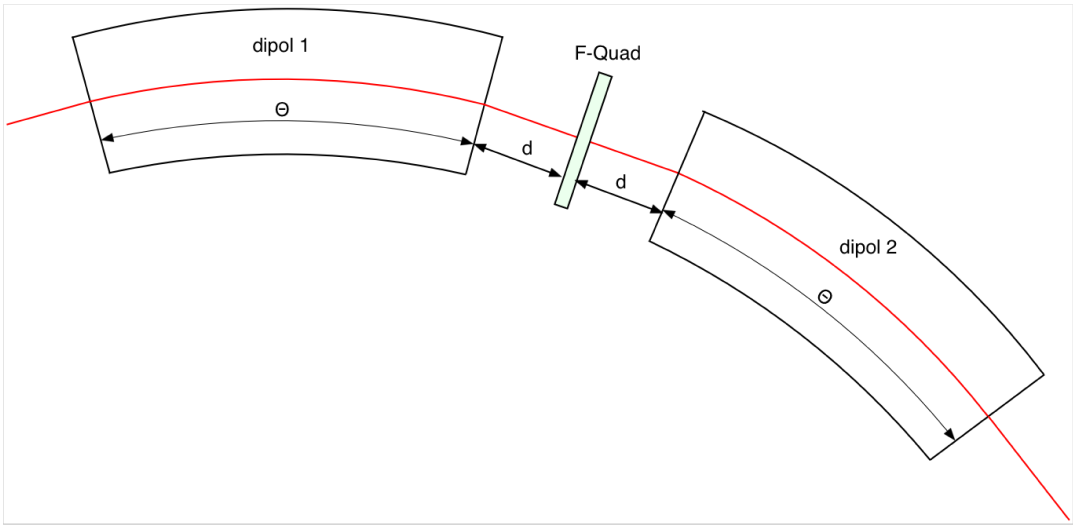
Accelerator Physics II

SS 2019

3.4.2019

Achromatic Bend

As youlearned in the lectures, any dipole "creates" dispersion, the orbit depends on the momentum deviation $\delta = \frac{\Delta p}{p_0}$. For many applications it is very interesting to create a "bend", that is deflection angle, without creating dispersion. To say it more precisely: if you enter the bend with D=0 and D'=0, you would like to have the same after the bend. In fact this is possible if you split the bend in two halfs and add a quadrupole in the center. See the figure.



First task: calculate the dispersion function at the end of bend and show that a focal length of the central quadrupole f_Q exists which makes D=D'=0.
The length of the dipoles is L_D, the bending radius ρ and thus the deflection angle of one dipole θ=L/ρ. We approximate the Quad by a thin lens.

How to : write down the 3x3 matrices for the bending plane and multiply...

$$M_{dipol}(s) = \begin{pmatrix} \mathrm{Cos}(\theta) & \rho\,\mathrm{Sin}(\theta) & \rho\,(1-\mathrm{Cos}(\theta)) \\ -1/\rho\,\mathrm{Sin}(\theta) & \mathrm{Cos}(\theta) & \mathrm{Sin}(\theta) \\ 0 & 0 & 1 \end{pmatrix} \quad (1)$$

Thin lens and drift spaces should be obvious.

Second task: make a plot of D(s) and D'(s) from s=0 to the end of the bend and show and understand how the dispersion compensation works.

The only difference is that you have to write down matrices up to point “s” and not just the end. More a bit of Fleissarbeit... Piecewise ?

Question: Why is a sequence of such achromatic bends alone not suited to make an achromatic ring (or more precisely : a ring with dispersion free sections) ? Which essential is missing ? Was there something with the "trace" ? There are two planes, both have to be stable.

How to include that ? Hint : you need three quads. Try to find a "stable, dispersion compensated" solution for a infinite series of “cells”. If you get it, you have designed a "double bend achromat" or "Chasman-Green-Lattice".

Alternative question : show that you cannot make an “achromatic displacement” that way. If you turn around the second dipole such that θ_2= - θ_1, the beam is parallel at the exit to the incoming beam but displaced in x. Just copy and paste and reverse the sign of ρ and/or θ in the second dipole. (That’s where a sign of ρ is needed). You should not get a solution for the f_Q. There is a way of doing it by having at least two quads between the dipols. If you like, find out how.