Homework for Beam-based Diagnostics USPAS Knoxville, TN, January 2019

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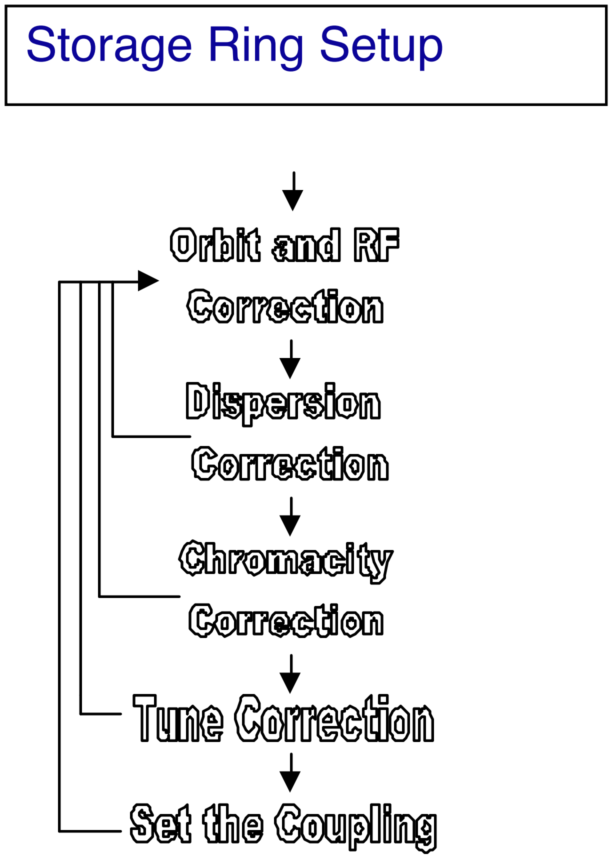
Web server

– The primary webpage for the whole class is http://www2.als.lbl.gov/als_physics/csteier/uspas19/
– All lectures, computer classes, homework assignments, … are, or will be posted there
– Specifically, homework can be accessed from http://www2.als.lbl.gov/als_physics/csteier/uspas19/compuclass.html

Monday: Motivation for Homework



Left: Simplified flow diagram for setup of storage ring lattice. Steps usually need to be done iteratively (because of hysteresis, …). This homework example addresses simplified dispersion and chromaticity correction.

Dispersion: $\eta_x = \Delta x / (\Delta p/p)$

Chromaticity: $\zeta = \Delta \nu / (\Delta p/p)$

Momentum compaction factor:

$\alpha = (\Delta L/L) / (\Delta p/p)$

Computer Homework #1 (due Tuesday)

Computer Homework #1: Dispersion & Chromaticity – using ALS as example

Given the following middle layer commands:

```
startup_bbd;    % Initialize Matlab middle layer
setpathals;     % Initialize middle layer for ALS Storage Ring – Important
                % Ignore warning about iGptools, those are not
                % necessary for your purpose (multibunch feedbacks)
x = getam('BPMx');  % Horizontal orbit at BPMs(121x1)
RF = getrf;         %  Get the RF frequency (MHz)
setrf(RF);          %  Set the RF frequency (MHz)
Tune = gettune;     %  Tune [NuX; NuY]
alpha = getmcf;     %  Momentum compaction factor
quad_curr = getpv('QF');  % get quadrupole strength for ‘QF'
        % similar for 'QD', ‘QDA', 'QFA'
setpv('QF',quad_curr); % set quadrupole current – also 'QD', …
sext_curr = getpv('SF');  % get sextupole strength for 'SF’ % similar for 'SD'
setpv('SF',sext_curr); % set sextupole current – also 'SD', …
```

Computer Homework #1 (due Tuesday)

Write a Matlab script to (for the ALS, i.e. after using >>setpathals):

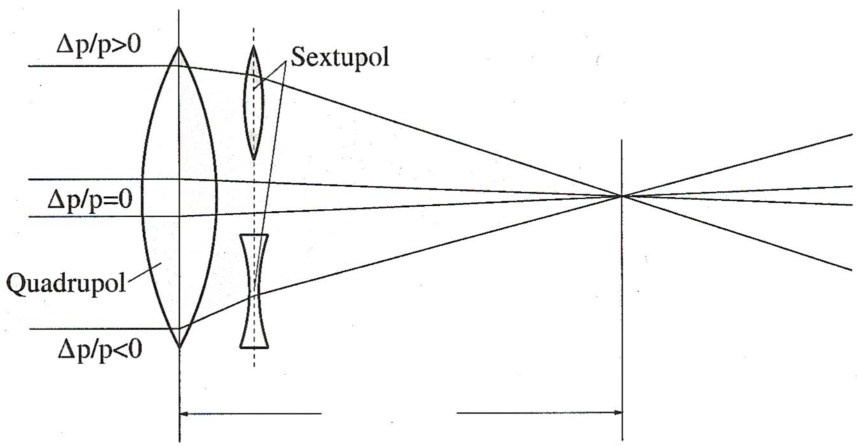
-> select 'Storage Ring'

1. Plot (see >>help plot) the horizontal dispersion function: $\eta_x = \Delta x / (\Delta p/p)$. Calculate the dispersion yourself, based on calls on slide 4 (getam('BPMx'), …).

   Note: $(\Delta p/p) = -(1/\alpha)(\Delta f/f)$, Use: $\pm 0.1\%$ energy change
2. Plot the horizontal tune versus energy offset (compute tune at [-.4% -.2% 0 .2% .4%] energy changes – again: $(\Delta p/p) = -(1/\alpha)(\Delta f/f)$)
3. Compute the horizontal chromaticity by using a numerical derivative around 0 or a (linear) fit (>>help polyfit)
4. Change each sextupole family (SF, SD) one at a time (by 1%) and determine which family is more effective to correct the horizontal chromaticity. Provide a guess why this is the case (>>modelbeta('SF'), >>modelbeta('SF'), >>modeldisp('SF'), >>modeldisp('SD') and attached slides 6+7 should be a help).
5. Test sensitivity of dispersion to different quadrupole families ('QF', 'QD', 'QFA', 'QDA'). Change one quadrupole family at a time by 1.0%, plot relative change in dispersion. Which family has biggest effect. Provide a guess why this is the case (hint: dispersion at quadrupole location).

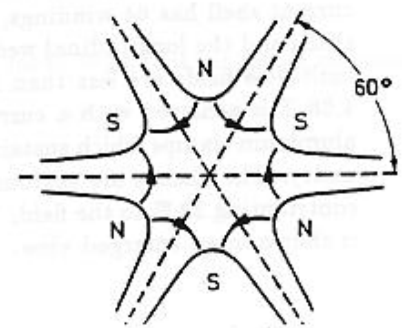
Chromatic Aberration Correction

By including dispersion and sextupoles it is possible to compensate (to first order) for chromatic aberrations



The sextupole gives a position dependent Quadrupole

$$B_x = 2Sxy$$
$$B_y = S(x^2 - y^2)$$



Chromatic Aberration Correction

Chromaticity, ν', is the change in the tune with energy

$$\nu' = \frac{d\nu}{d\delta}$$

Sextupoles can change the chromaticity

$$\Delta\nu_x' = \frac{1}{2\pi}\left(\Delta S \beta_x D_x\right)$$

$$\Delta\nu_y' = -\frac{1}{2\pi}\left(\Delta S \beta_y D_x\right)$$

where

$$\Delta S = \left(\partial^2 B_y \middle/ \partial x^2 \right) \cdot \text{length} \Big/ (2B\rho)$$

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