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Synchrotron Radiation — Exercises 2

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1 Applications

Why are synchrotrons important for science?

Mostly Research purpuses:

- BIOLOGY
- chemistry
- Medicine
- Farmaceutic science
- photolitography
- High Energy physics

Short wavelengths allows to investigate matter...

2 Orbit Correction

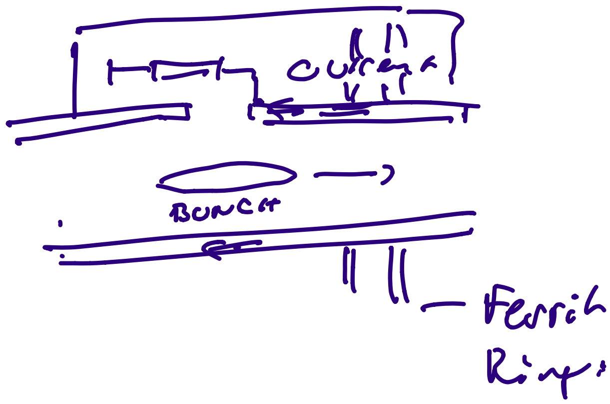
Which devices are used to measure and correct the orbit inside a synchrotron?

- Beam position monitors
- correct the orbit with dipoles
  & kickers for fast corrections
- additional coils in quadrupole magnets
- mechanical displacement of quadrupoles

3 Instrumentation

How would you measure the bunch length in a synchrotron?

Wall Current Monitor



Streak camera on synchrotron light from a dipole magnet

4 Detection

What possibilities exist to detect X-Rays?

- CCD
- PHOTODIODS
- SCINTILLATORS
- PHOTOGRAPHIC FILMS
- ionization chambers

5 Monochromators

What dispersive element is used to monochromatize X-Rays? What differences exist to monochromators for visible light?

A crystal can be used to monochromatize X-Rays.

Differences: - wavelenghts
- condition on input and output of light
- for visible light we use mechanicaly fabricated grating
- for X-rays we used grating made of atoms

6 Refractive Index

The passage of electromagnetic radiation can be described classically by an index of refraction. What are the properties of the index of refraction of most materials at X-ray wavelengths?

$$n = 1 - \delta + i\beta$$

$$\delta, \beta \ll 1$$

7 DLSRs

How do longitudinal gradient bends contribute towards the goal of achieving a lower horizontal emittance in a diffraction limited storage ring?

$$\varepsilon \propto \int D^2(s)\, B^3(s)\, ds$$

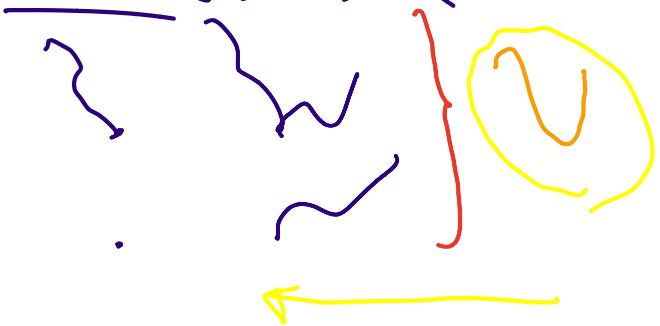
cc. to design the Bending magnets so that largest magnetic fields corresponde to lowest despersion region.

8 Diffraction

Why is diffraction often used in place of imaging when using X-rays?
What is the *phase problem* in X-ray diffraction?

X rays can be used because they have approximately the same order of magnitude in wavelength than the distance between cristal plane ⇒ use diffraction

Intensity, ~~polarization~~, angle ~~of incidence~~, phase



9 Crystals

Which of the following are crystalline? More than one answer is possible.

- ◯ The glass on the screen of my mobile phone
- ⊗ The sapphire glass on an expensive watch
- ⊗ Asbestos
- ⊗ Icing sugar

10 Absorption and Diffraction

A scientist wants to record a diffraction pattern of a silicon crystal at a photon energy of 8 keV. What is the optimum thickness of the crystal, that maximizes the intensity of the diffracted spot?

Hint: you can find the mass absorption coefficient of silicon on page 1-41 (page 49 in the PDF) of the X-Ray Data Booklet, and the density on page 5-5 (page 153).

$\mu = 100\ cm^2/g$

$\rho = 2{,}33\ g/cm^3$

$\mu = \frac{1}{\mu \cdot \rho}\ cm$

$$I = \underbrace{I_0 \cdot e^{-\frac{x}{\mu}}}_{\text{ABSORPTION}} \cdot \underbrace{(\sigma \cdot x)}_{\text{SCATTERING}}$$

$\downarrow \frac{d}{dx}$

$$0 = \sigma \cdot e^{-\frac{x}{\mu}} - \frac{1}{\mu} \cdot \sigma x e^{-\frac{x}{\mu}}$$

$$x = \mu = \frac{1}{233} cm = 43\ \mu m$$