Corpuscular optics 2017 (JM De Conto) - 2 pages

Exercise 1. We consider a $^{8}O^{3+}$ ion. Its kinetic energy is 400 MeV/nucleon. The energy at rest for the nucleon is 0.940 GeV, the speed of light is $3.00 \cdot 10^{8} m/s$. Give the numerical value of the Lorentz β and γ coefficients and the magnetic rigidity of the particle with 3 significant digits

Exercise 2. A parallel-to-parallel system is defined by the following property: any initial beam parallel to the axis exits parallel to the beam axis. Give the general form of the 2x2 transfer matrix (3 coefficients among 4) supposing the initial momentum is 1 and the final momentum is 2 (arbitrary units).

Exercice 3. A magnetic quadrupole has a bore radius of 40 mm, a length 25 cm. The beam rigidity is 3 Tm. What must be the field on the pole to have a focal length equal to 2 meters? Give the numerical value of the transfer matrix in the focusing plane, with 3 significant digits.

Exercise 4: FODO cell

Consider a FODO cell made of: a focusing thin lens (focal length f), a drift space (length L), a defocusing thin lens (focal length f) and a drift space (length L)

- Compute M, the transfer matrix of the FODO cell
- Supposing you can write M on the TWISS form (i.e. this means that the motion is stable), and supposing μ to be the betatron phase advance per FODO cell (and $\mu > 0$), give $sin(\mu/2)$ versus L and f. Deduce the condition to have a stable motion for FODO in general.

Exercise 4A. We consider a symmetric system. The first half transfer matrix is $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$. Your boss has computed the transfer matrix of the second half, but hesitates between $\begin{bmatrix} -2 & -1 \\ -3/2 & -1/2 \end{bmatrix}$ and $\begin{bmatrix} -2 & -1 \\ -3/2 & 1/2 \end{bmatrix}$. What is the correct answer, among these two matrices?

Exercise 5. Spectrometer (a very bad spectrometer, only for the exercise).

We consider a spectrometer. It is made of a drift space (length L_1), a defocusing thin lens (focal length f), a 45-degree dipole (radius ρ) and a drift space (length L_2). The transfer matrix of the dipole is $\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & \rho \\ -\frac{1}{\rho} & 1 \end{bmatrix}$

- Give a relation between L_1 and L_2 in order to have point-to-point imaging
- Suppose now, in addition to the point-to-point imaging, that the beam has a waist $\alpha_0 = 0$ at the beginning of the first drift. Give a relation between f and ρ in order to have $\alpha_1 = 0$ at exit (waist-to-waist imaging).
- Under these conditions, what is the magnification?
- We wish L_1=L_2=L. Express L versus ρ