Computer Lab: More madx with doglegs and achromats

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1. Dogleg

   (a) A dogleg (as illustrated in slide 5 of the Fri PM lecture) is a pair of opposite-bend dipoles separated by a drift section. Last Friday we learned all the tools to build such a dogleg (with only three elements) in madx.

   (b) Construct a weak dogleg with 3° SBEND (sector bend) elements of length 2.0 m, with a drift length of 6.0 m between them. Track $\eta_x = 0, \eta'_x = 0$ through the dogleg and compare the results to the class slides.

   (c) Construct a strong dogleg with 30° SBEND (sector bend) elements of length 2.0 m, with a drift length of 6.0 m between them. Track $\eta_x = 0, \eta'_x = 0$ through the dogleg and compare the results to the class slides. What is the requirement for the weak dogleg approximation to apply?

   (d) Build an achromatic dogleg with four $\pi/2$ insertions instead of the drift to see that the dogleg indeed moves the beam without dispersion. Plot the dispersion for this achromatic dogleg in madx to see that it closes, similar to the plot on slide 9 of the Friday PM class notes.

2. Double Bend Achromat

   (a) Construct a double bend achromat with the parameters given in class (slide 21 of the Friday PM class notes) in madx: $L = l = 2\,\text{m}$, $\theta = 0.01\,\text{rad}$, $f = (L+2l)/4 = 1.5\,\text{m}$, $(KL)_{\text{quad}} = 0.677\,\text{m}^{-1}$.

   (b) Track $\eta_x = 0, \eta'_x = 0$ through the achromat and demonstrate that it is an achromat by reproducing the figure of η_x vs s on slide 21.

   (c) Can a system like this be periodic in both β_x and β_y? That is, can you construct an achromatic bending "cell" out of just a DBA?

   (d) Add an extra defocusing quadrupole on each end of the DBA of a "reasonable" strength (e.g. with focusing length on the order of 2-3 times the spacing of the elements to avoid overfocusing), then a drift and a half a focusing quadrupole (with the same strength as the defocusing quadrupole) to each end. Use madx to find the periodic cell boundary conditions. Plot the periodic lattice functions $(\beta_x, \beta_y, \eta_x)$ for your new DBA lattice cell.