USPAS FEL 2021 Homework Set 3

3.1 Table 4.1 of the text book compares the differences between planar and helical undulators. With your knowledge of the dimensionless K parameter and the JJ factor, plot the ratio of the FEL parameter ρ of a helical undulator over the FEL parameter ρ of a planar undulator of the same K as a function of K. Explain how this increase in the FEL ρ going from planar to helical undulators affect the FEL performance.

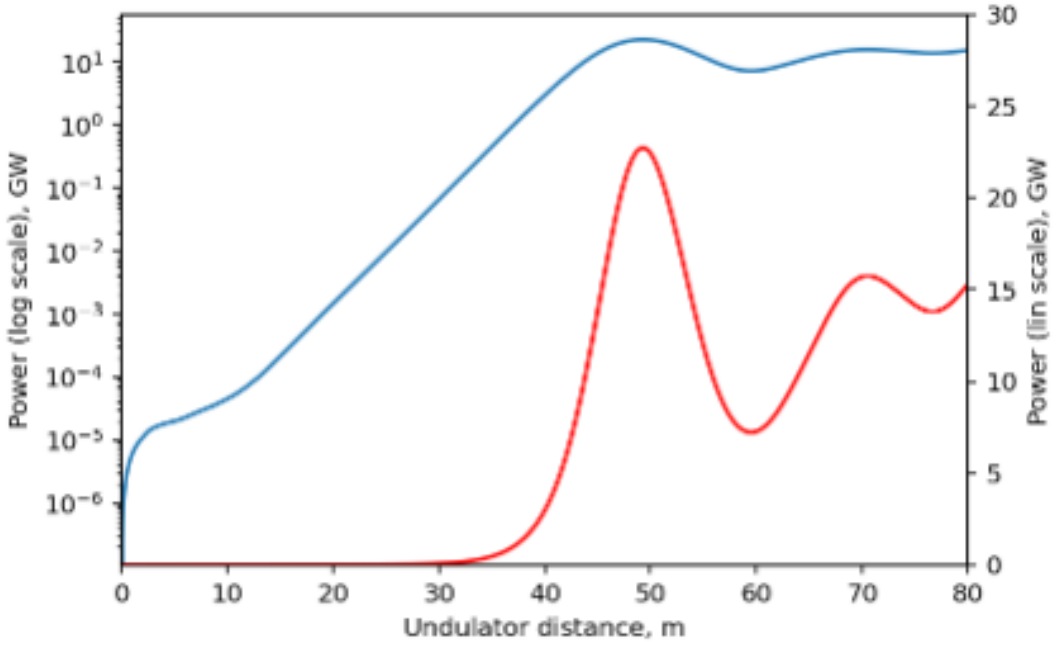
3.2 The figure below shows the plot of SASE power versus distance for the first LCLS lasing, with power on a log scale on the left (blue) and linear scale on the right. The parameters for the fist LCLS lasing are: beam energy = 13.6 GeV, undulator period = 3 cm, K = 3.5, lambda = 1.5 Angstrom, Ipeak = 3 kA, norm_emit = 0.4 mm-mrad, energy spread = 0.01% and average focusing beta = 18 m.

a) Estimate the start-up noise power

b) Estimate the exponential gain length

c) Estimate the synchrotron period

d) From the result of c), calculate the FEL bucket half-height



3.3 Explain the reason behind expressing the equivalent power of periodically bunch beam with the following approximation (slide 44 of FEL_2 lecture note).

$$P_{eq}(0) \approx \rho P_b b^2(0)$$

3.4 The divergence of the X-ray FEL beam can be approximated by the following expression.

$$\sigma_{r'} \approx \frac{\sigma_r}{L_G}$$

Using the expressions for the 1D gain length and ρ parameter and equating the radiation beam radius to the electron beam radius, derive an expression for radiation beam divergence as a function of radius.