US MCC 2025 School (UChicago)
Homework Day 2 Assignments

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Proton Driver Bunch Rotation

1: Consider a 10 GeV proton bunch with 2 ns bunch length with a Laslett tuneshift parameter of -0.4.
a) What will the Laslett tuneshift parameter be if (all other parameters the same) the bunch length was at 20 ns and the beam energy was 5 GeV?
b) What would the Laslett tuneshift parameter be if the bunches were split into four and the beam emittances were also a factor of four smaller?
c) What would the impact on the Laslett tuneshift parameter if the longitudinal beam profile were changed from a Gaussian distribution to the following bimodel distribution:

$$\frac{1}{4.58\sigma_z}\exp\left[\left(\frac{z}{2\sigma_z}\right)^2-\left(\frac{z}{2\sigma_z}\right)^4\right]$$

2: Let's consider the Hamiltonian for synchrotron (pendulum) motion. Particles near the center of the RF bucket (i.e. small angles where the Hamiltonian approximates a harmonic oscillator) follow a phase-space ellipse in ϕ and δ. Let $\hat{\phi}$ and $\hat{\delta}$ be the semi-major and semi-minor axises of that ellipse, such that $H(\hat{\phi},0)=H(0,\hat{\delta})=\hat{H}$.

Now let's imagine the voltage is suddenly jumped up from V_1 to V_2. After a $\pi/2$ synchroton oscillation, show that new coordinate positions are

$$(\hat{\phi},0)\longrightarrow(0,\sqrt{V_2/V_1}\hat{\delta})$$
$$(0,\hat{\delta})\longrightarrow(-\sqrt{V_1/V_2}\hat{\phi},0)$$

for counterclockwise motion (without loss of generality)