CON 89-10
October 27, 1989
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Damping Partition Numbers for Distorted Orbits

The damping partition numbers depend on the displacement of the closed orbit in the quadrupoles. Consequently the partition numbers (and therefore damping times, emittances, and energy spread) are in general different for electrons and positrons if the orbits are electrostatically distorted. The effect is computed by

1. Finding the closed orbit for the configuration of separators of interest,
2. Determining the displacement (x_i) of the orbit in each quadrupole of length l_i and strength k_i. The effective bending radius of each quad is $\rho = \frac{1}{x_i k_i}$.

Then following Sands,

$$D = \frac{\sum_i \eta_i \left(G_i^3 + 2G_i k_i\right) l_i}{\sum_i G_i^2 l_i} \rightarrow \frac{\sum_i \eta_i \left(G_i^3 + 2x_i k_i^2\right) l_i}{\sum_i \left(G_i^2 l_i + (k_i x_i)^2 l_i\right)}.$$

The sum is over dipoles and quadrupoles and $G = 1/\rho$. For opposite sign particles $x_i \rightarrow -x_i$. Then $J_x^{\pm} = 1 - D(\pm x)$ and $J_\epsilon^{\pm} = 2 + D(\pm x)$. J_z is independent of pretzel amplitude since there is nominally no vertical dispersion. Horizontal emittance depends on both J_x and $\int G^3 H ds$. The contribution due to the effective bending in the quads is included in the form of $\sum (k_i x_i)^3 H_i l_i$. Energy spread, longitudinal and horizontal damping times and horizontal emittance all depend on the partition numbers and are computed for both signs of particles. Vertical damping times depend on the total energy radiated and the effect of the pretzel is quite small.

The necessary code has been added to Dimat so that the damping characteristics of any lattice can be explored. The results for the HEP lattice G9915a964.9a7_3s are summarized both for the case where beams collide at L0(luminosity see Fig. 1) and when they are separated at L0(injection see Fig. 2).

Both beams are assumed to have the same energy even though this is not strictly true for the case of the injection optics. Then $(E_+ - E_-)/E \sim 3.6 \times 10^{-4}$. The damping time scales as 1/E and the emittance and energy spread as E^2. The effect of the differential energies is apparently less significant than that of the differential closed orbits.(see table)

G9915a964.917_3s 5.17GeV			
	No Pretzel	Injection(+/-)	Luminosity(+/-)
J_x	0.98953	1.0380/0.9411	0.9791/1.0000
J_ϵ	2.01047	1.9620/2.0589	2.0209/2.0000
τ_x (ms)	28.5	27.2/30.0	28.8/28.2
τ_z	28.2	28.1	28.2
τ_ϵ	14.0	13.8/14.5	14.2/14.1
$\sigma_E/E \times 10^{-3}$	0.599	0.605/0.591	0.597/0.600
$\epsilon_x(mm-mrad)$	0.1767	0.1679/0.1851	0.1783/0.1746