Simulations for FCC-ee beam self-polarization - cont.

Contents:
- $P$ vs. $Q_{syn}$
- Reducing $\tau_{10\%}$

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October 24, 2017
Yokoya (1983) and Mane (1990) predict, under the assumption resonances are well separated, energy spread would enhance the strength of synchrotron side bands by the “enhancement factor”

$$\xi = \left( \frac{a\gamma}{Q_{syn} \sigma_E} \right)^2$$

At very high energy and in presence of unavoidable alignment and/or field errors the Sokolov-Ternov effect is overwhelmed by the spin diffusion. Derbenev et al. (1979) predict a polarization resurrection if the condition

$$F_D \equiv \frac{(a\gamma)^2 T_{rev}}{\tau_p Q_{syn}^3} \ll 1$$

is satisfied.

$\sim$ large $Q_{syn}$ may be desirable at high energy and/or large $\sigma_E$. Obtaining larger synchrotron tunes while keeping the RF voltage to reasonable values requires increasing the momentum compaction factor.
Toy ring 60/60 degrees FODO

Wigglers OFF - $Q_s=0.1$

$$V_{RF}=91 \text{ GV}$$

$$\xi: 1.5 \rightarrow 0.17$$

$$F_D: 0.2 \rightarrow 8 \times 10^{-3}$$

$$\rightarrow 0.018$$

$$\rightarrow 2.7 \times 10^{-4}$$
Toy ring 90/90 degrees FODO

Toy ring $90^0/90^0$ optics with $Q_x=0.13$, $Q_y=0.2$, $Q_s=0.081$

Toy ring $90^0/90^0$ optics with $Q_x=0.13$, $Q_y=0.2$, $Q_s=0.024$
Olde-san ring $\beta_y^*=1\text{mm}$, 90/90 degrees FODO

\[
\begin{align*}
\text{Oide } 90^0/90^0 \text{ optics with } Q_x &= 0.1, Q_y = 0.2, Q_s = 0.05 \\
\text{Oide } 90^0/90^0 \text{ optics with } Q_x &= 0.1, Q_y = 0.2, Q_s = 0.025
\end{align*}
\]
Reducing $\tau_{10\%}$

In general

$$(\sigma_E/E)^2 = \frac{C_q C_\gamma E^4}{2\pi J_e F \gamma^3 \tau_p U_{loss}} \frac{1}{\tau_{10\%}}$$

$F \equiv \frac{5\sqrt{3}}{8} \frac{r_e \hbar}{m_0 C}$

$\sim$ small $\tau_p$ is at price of a higher $U_{loss}$ and/or $\sigma_E$. 
σ_E = 247 MeV
U_{loss} = 278 MeV/turn
τ_{10%} = 1 minute