AS Sources Homework
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1. Space Charge Derivation: Derive the space charge equations on slides 30 and 31. Show that the SC forces go to zero as γ gets large.

2. Derive the Spin Rotation equations on slide 111:

$$\theta_{Bend} = \frac{B(kG)L(m)}{33.359E(GeV)} \ rad \qquad (14')$$

$$\theta_{prec} = \frac{E(GeV)}{0.44065}\theta_{Bend} \qquad (15')$$

$$\phi_{rot} = \frac{B(kG)L(m)}{33.359E(GeV)} \qquad (16')$$

$$\theta_{prec\_\mathcal{E}} = \left[\left(\frac{\gamma^2-1}{\gamma}\right)\left(\frac{g}{2}\right)-\gamma\right]\theta_{Bend\_\mathcal{E}} \qquad (22)$$

The Lorentz force is given by Jackson (11.168) in cgs units as

$$\frac{d\vec{\beta}}{dt} = \frac{e}{\gamma mc}[\vec{\mathcal{E}} + \vec{\beta}\times\vec{B} - \vec{\beta}(\vec{\beta}\bullet\vec{B})] \qquad \{\text{cgs}\} \qquad (1)$$

wherein vectors are indicated by an arrow, $\vec{\mathcal{E}}$ is the electric field, $\vec{\mathrm{B}}$ the magnetic field, and $\vec{\beta} = \frac{\vec{\mathrm{v}}}{\mathrm{c}}$. Convert (1) to MKS by replacing $\vec{\mathrm{B}}$ by $\mathrm{c}\vec{\mathrm{B}}$; also multiply both sides by c to convert $\vec{\beta}$ to $\vec{\mathrm{v}}$ and change e to q for aesthics

$$\frac{d\vec{v}}{dt} = \frac{q}{\gamma mc}[c\vec{\mathcal{E}} + \vec{v}\times\vec{B} - \vec{\beta}(\vec{v}\bullet\vec{B})]. \qquad \{\text{MKS}\} \qquad (2)$$

The BMT equation is given by Jackson (11.170) in cgs units as

$$\frac{d\vec{s}}{dt} = \frac{e}{mc}\vec{s}\times[(\frac{g}{2}-1+\frac{1}{\gamma})\vec{B} - (\frac{g}{2}-1)\frac{\gamma}{\gamma+1}\vec{\beta}(\vec{\beta}\bullet\vec{B}) - (\frac{g}{2}-\frac{\gamma}{\gamma+1})\vec{\beta}\times\vec{\mathcal{E}}]\ . \quad \{\text{cgs}\} \qquad (3)$$

Convert (3) to MKS by replacing $\vec{\mathrm{B}}$ by $\mathrm{c}\vec{\mathrm{B}}$ and change e to q

$$\frac{d\vec{s}}{dt} = \frac{q}{m}\vec{s}\times[(\frac{g}{2}-1+\frac{1}{\gamma})\vec{B} - (\frac{g}{2}-1)\frac{\gamma}{\gamma+1}\vec{\beta}(\vec{\beta}\bullet\vec{B}) - (\frac{g}{2}-\frac{\gamma}{\gamma+1})\frac{\vec{\beta}\times\vec{\mathcal{E}}}{c}]. \quad \{\text{MKS}\} \qquad (4)$$

For c=2.998x10^8 m/s, mc^2=0.511 MeV, $(\frac{\mathrm{g}}{2}-1) = 1.16\mathrm{x}10^{-3}$, BL in units of kG-m, and E in GeV (14)-(16) become

3. Laser Power: Assuming QE = 2e-5 for a copper cathode, how much peak and average laser power is required to generate 250pC of charge at 120 Hz in the LCLS? How much laser energy is absorbed within a depth of one wavelength of the surface?

4. What is the underlying physics for Moeller scattering? How does Moeller scattering work?

5. Extra Credit: Thermal Diffusion, slides 119-121: What is the energy distribution as a function of time in a copper cathode at t=2ps for an incident 2 ps long laser pulse with an energy of DU (joules)?