Physics 506 **Winter 2008**

Homework Assignment #12 — Due Thursday, April 10

Textbook problems: Ch. 14: 14.4, 14.5, 14.8, 14.11

14.4 Using the Liénard-Wiechert fields, discuss the time-averaged power radiated per unit solid angle in nonrelativisic motion of a particle with charge e, moving

a) along the z axis with instantaneous position $z(t) = a\cos\omega_0 t$.

b) in a circle of radius R in the x-y plane with constant angular frequency ω_0.

Sketch the angular distribution of the radiation and determine the total power radiated in each case.

14.5 A *nonrelativistic* particle of charge ze, mass m, and kinetic energy E makes a *head-on* collision with a fixed central force field of finite range. The interaction is repulsive and described by a potential $V(r)$, which becomes greater than E at close distances.

a) Show that the total energy radiated is given by

$$\Delta W = \frac{4}{3}\frac{z^2e^2}{m^2c^3}\sqrt{\frac{m}{2}}\int_{r_{\min}}^{\infty}\left|\frac{dV}{dr}\right|^2 \frac{dr}{\sqrt{V(r_{\min}) - V(r)}}$$

where $r_{\min}$ is the closest distance of approach in the collision.

b) If the interaction is a Coulomb potential $V(r) = zZe^2/r$, show that the total energy radiated is

$$\Delta W = \frac{8}{45}\frac{zmv_0^5}{Zc^3}$$

where v_0 is the velocity of the charge at infinity.

14.8 A swiftly moving particle of charge ze and mass m passes a fixed point charge Ze in an approximately straight-line path at impact parameter b and nearly constant speed v. Show that the total energy radiated in the encounter is

$$\Delta W = \frac{\pi z^4 Z^2 e^6}{4m^2c^4\beta}\left(\gamma^2 + \frac{1}{3}\right)\frac{1}{b^3}$$

This is the relativistic generalization of the result of Problem 14.7.

14.11 A particle of charge ze and mass m moves in external electric and magnetic fields $\vec{E}$ and $\vec{B}$.

a) Show that the classical relativistic result for the instantaneous energy radiated per unit time can be written

$$P = \frac{2}{3}\frac{z^4e^4}{m^2c^3}\gamma^2[(\vec{E} + \vec{\beta}\times\vec{B})^2 - (\vec{\beta}\cdot\vec{E})^2]$$

where $\vec{E}$ and $\vec{B}$ are evaluated at the position of the particle and γ is the particle's instantaneous Lorentz factor.

b) Show that the expression in part a can be put into the manifestly Lorentz-invariant form

$$P = \frac{2z^4 r_0^2}{3m^2 c} F^{\mu\nu} p_\nu p^\lambda F_{\lambda\mu}$$

where $r_0 = e^2/mc^2$ is the classical charged particle radius.