PHYSICS 323 ELECTROMAGNETISM

May 3, 2020 Problem Set 4 These 4 problems are due **in Canvas Tuesday, May 12 11 am**

Please put your name and section number on the first page of your solutions.

1. *Antenna problem*

A wire of length L has its center at the origin, and lies along the z axis. The current carried by the wire is of the form $I(z,t) = I_0 \cos(\omega t) \cos(\frac{\pi z}{L})$. Consider positions in the radiation zone.

(a) Compute $\mathbf{A}(\mathbf{r}, t)$.

(b) Compute $\mathbf{E}(\mathbf{r}, t)$ and $\mathbf{B}(\mathbf{r}, t)$.

(c) Compute the angular distribution of radiated power.

2. *Magnetic dipole radiation- two loops*

Consider a circular current loop in the xy plane of radius b as in Section 11.1.3. Suppose there is another parallel identical loop placed a distance d above the first loop. The directions of the currents in the two loops are both counterclockwise. The long wavelength approximation is applicable.

(a) Compute the total vector potential $\mathbf{A}$ at positions in the radiation zone.

(b) Compute the total magnetic field in the radiation zone.

(c) Compute the angular distribution of radiated power, and discuss the dependence on the value of d.

3. *Pulsar*

A pulsar is a spinning neutron star where the star?s magnetic-dipole axis is misaligned by angle α with its spin axis. The equation for the Poynting vector (11.39) is modified by including a term $\sin^2\alpha = 1/2$. A typical neutron star has radius 10 km, and the magnetic field at the pole is 10^{12} Gauss.

(a) The famous Crab pulsar has a period of 33 ms. Estimate how much power it is radiating.

(b) The rarer magnetar has pole field or around 10^{15} Gauss and suppose the period is 1 ms. Estimate how much power it is radiating.

4. *Larmor radiation* A beam of 2 keV electrons is stopped with constant deceleration in a distance of 0.01 cm.

(a) Compute the total energy of radiation emitted by each electron.

(b) Determine the ratio of the emitted energy to the initial electron energy. Use this ratio to find the radiated power for an X-ray machine witj 300 watts of power input to accelerate the electrons.

(c) Compute the maximum intensity (in Watts/meter^2) of the radiation at a distance 20 cm from the stopping target.