PHYS 115

Rec. Assignment #7

May 30, 2007

Field lines of moving charges

Imagine a charged particle moving in free space. In order to define the movement, we can say that we are at rest relative to some fixed reference point (lab frame) and the particle is the one doing the moving (why is this distinction important?). If we sit at this point P and observe the electric field it gives off, we find that the field given at P depends on the particles position sometime in the past $\frac{|\vec{r}|}{c}$. This is due to the finite speed of the electromagnetic wave c.

At all times during this experiment, let $c = 1$ (Gaussian units).

First animate the particles motion. Let the particle move in a fixed circle of radius 10. Use a time step of $\Delta t = .1$ and give the particle a high speed, say $v = .75c$. Visually check at this point to see if the particle moves in the expected manner.

Now we want to draw the field lines for the particle at each time step. These waves propagate out a fixed speed c radially from the particle current location. Since it is impossible to draw *all* the field lines, we are only going to draw the lines at fixed angles. Let m be the number of field lines you want to draw (10 is a good starting number). Sub-divide 2π into m fixed angles. These angles, ϕ_i are the directions the field lines will propagate from your particle.

You now have a list of m angles. Create a list of m field lines, that have space for about 100 vector points. At each time step, remove the last point in each list. Now let each remaining point move forward by $c\Delta t$ in the direction ϕ_i. Finally add a new point to the beginning of the list at the current particle location. If this is done correctly, you should see field lines emanating from the particle.

Questions:

1. Observe the far field behaviour. What does it mean physically when the field lines are bunched together? What about when they are far apart?

2. Use the fact that electromagnetic waves are, in reality, light sources. Now let your particle move faster then the speed of light. Physically describe what is happening. Is causality violated?