PHY 420 Spring 2021

Homework 8—due by 9:00 PM, Friday, June 4

There is no late deadline for this homework due to the Final Exam.

1. In class, we learned that electric and magnetic fields do not have separate existences — what looks like an electric field in one frame will be a mixture of electric and magnetic fields in another frame. However, we also learned that a pure electric field in one frame cannot be a pure magnetic field in another frame. Prove this quantitatively, by figuring out what condition would need to be satisfied in order for a purely electric field in frame K to be a purely magnetic field in frame K'.

2. **Do not begin this problem until after Tuesday's class this week.**

In class, we looked at the time dependence of the fields E_1, E_2, and B_3 (at a fixed observation point). An alternative is to look at the spatial distribution of the fields at a fixed instant in time (or, as Jackson puts it, "relative to the instantaneous present position of the charge in the laboratory"). Show that the electric field in terms of the present position of the charge is then given by

$$\vec{E} = \frac{q\vec{r}}{r^3\gamma^2(1-\beta^2\sin^2\psi)^{3/2}}$$

where r is the radial distance from the present position of the charge to the observer (as shown in Figure 11.8 on page 559 in Jackson), and the angle $\psi = \cos^{-1}(\hat{n}\cdot\hat{v})$ is between the direction of $\hat{n}$ and $\vec{v}$, where $\hat{n}$ is a unit radial vector from the present position of the charge to the observation point (i.e., a unit vector along the direction of $\vec{r}$), and $\vec{v}$ is along the positive x_1-axis (see Figure 11.8 in Jackson).

You may write by hand and scan as a single PDF, or write in latex (using the template file provided) or Word, and generate PDF. Please submit one PDF file only. Only questions and sub-parts that are numbered clearly, with numbers corresponding to those in this document, will be graded. See the syllabus for more detailed rules. This homework is shorter to allow you time to work on your Formal Write-up.

Note again that there is no late deadline for this homework due to the Final Exam.