7.1 Charged particle motion in two frames of reference

A positive charge $q$ is released from rest at the origin, in a uniform static electric field $E = E\hat{z}$ and a uniform static magnetic field $B = B\hat{x}$. Determine the trajectory of the particle by transforming to a frame in which the electric field is zero, finding the trajectory in that frame, and then transforming back to the original frame. Assume $E < B$ and relativistic particle motion.

7.2 Electromagnetic fields of a rotating planet

A planet of radius $a$ rotates with angular velocity $\omega\hat{z}$ relative to an inertial frame $K$ in which the planet’s center is at rest (here $\hat{z}$ is a unit vector parallel to the spin axis). According to a group of observers sitting on the surface of the planet and at rest with respect to it, there is no electric field at the surface, and the magnetic field is a dipole field with magnetic dipole moment $M = M\hat{z}$ located at the center of the planet. That is,

$$B' = \frac{3\hat{r} (\hat{r} \cdot M) - M}{a^3},$$

where $\hat{r}$ is a unit vector pointing radially outward from the planet’s center.

(a) What is the surface magnetic field, as measured in the inertial frame $K$?

(b) What is the surface electric field, as measured in the inertial frame $K$?

In parts (a) and (b) give your answers in spherical polar coordinates, and do not assume $\omega a \ll c$.

(c) What is the total charge $Q$ inside the planet according to measurements made in the frame $K$? To simplify the calculation assume $\omega a \ll c$. If you find a nonzero value for $Q$, explain why there is no contradiction with the fact that the group of observers measure no electric field anywhere on the surface.

7.3 Read sections 23-27 of Landau and Lifshitz.

After you have read these sections, for credit write “I have read sections 23-27”.

PHYS 532: Classical Electrodynamics

Homework Set 7 Due at the beginning of class, Friday March 20, 2015