Physics 323, Spring Quarter 2015
Electrodynamics: Homework Assignment 7

Turn in all problems and clearly note all constants and assumptions you use. (1-point penalty each otherwise)

Due 9:00 am Thursday May 21

1. (simple problem) An isotropic emitter of 2 GeV total-energy protons ("isotropic" and "2 GeV" in the rest frame of the emitter) moves with velocity β=0.6 in a trajectory radially away from the Earth.
a. Find the speed of a proton emitted towards Earth in the Earth's frame and in the emitter's frame.
b. Find the time it takes for a proton to reach the Earth in the Earth's frame and in the emitter's frame when the emitter is at a distance 10^{15} km from Earth.

2. (simple) A 20 year old captain of a spaceship moving at constant velocity β=1-0.002 passes near Earth. After one year of spaceship time, the captain sends a message back to Earth. By how many years have the people of Earth aged when the message arrives?

3. Suppose you heated a liter of helium liquid initially at 0.1°K by 4°K. Further suppose the charge-to-mass ratio e/m is unchanged during the heating (that is, e/m remains e/m_0).
a. How would the total charge of the liquid change during heating?
b. If the liter of liquid were spherical, and all the excess charge migrated to the surface of the sphere, find the increase in electrostatic energy.
c. How would you modify the e/m law to ensure charge doesn't change during heating?
Hints: Approximately, a liter of helium liquid becomes on vaporization 400 STP of gas. You can assume the kinetic energy is that of an ideal gas, and the gas atoms are moving non-relativistically.
This problem should help you appreciate that the total electric charge must be invariant.

4. An initially slowly-moving charged particle (charge q, mass m) enters the uniform-electric-field (**E**) of a Van de Graff particle accelerator. The particle is in the field region for time t measured in the laboratory.
a. Find the velocity of the charge on leaving the accelerator.
b. After acceleration, suppose the particle disintegrates into two fragments after a time t_0 (as measured in the particle's rest frame). How long did the particle take to disintegrate as viewed by the accelerator operator?

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