

Problemset 2

Physics 363
Apr. 9, 2008

Spring Quarter 2008
Due in class Wed. Apr. 16.

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Reading: Perkins Chapter 3 (4th Edition)

Norman Ramsey, Electric Dipole of the Neutron;

<http://arjournals.annualreviews.org/doi/abs/10.1146/annurev.ns.40.120190.000245>

Problems:

The first two problems are exercises to teach you useful search tools for HEP; please play with them a little (you can look up your friends, e.g.), but nothing written is required. These may be useful in researching your topics. The next 3 are typical of the relativistic kinematics we use all the time in HEP.

1. Find the Ramsey Annual Reviews Article above using Spires (<http://www.slac.stanford.edu/spires/hep/>)
2. Use the Los Alamos server to find papers on the neutron dipole moment (<http://arxiv.org/find>).
3. Consider a distant galaxy moving away from us at velocity β . A photon is emitted from the galaxy with energy E toward us. Find the energy of the photon as observed by us in terms of E and β . Find the wavelength observed in terms of the wavelength in the galaxy frame and β . How does your formula relate to the redshift, z , used by cosmologists? (The first part should take 3 or 4 lines at most- if it takes you longer come see me).
4. Consider the ('weak') decay of a top quark to a W boson and a b-quark. The W boson then decays (also weakly) to an electron and a neutrino. In an event recorded at Fermilab the 4-vectors of the observed particles are (in the metric (t,x,y,z)):

b-quark:	(136.0, 0.0, 0.0, 117.776)
electron:	(106.0, +40.0,-33.9, 91.796)
neutrino:	(106.0, -40.0,+33.9, 91.796)

where the z direction is along the direction of the Fermilab beamline and the x and y directions are perpendicular to it.

- (a) Find the 4-vector for the top quark.
 - (b) Calculate the mass of the top quark from these observations.
 - (c) Find γ and β for the rest-frame of the top quark.
 - (d) Transform the b-quark 4-momentum into the rest-frame of the top quark.
5. Ultra-high energy cosmic rays come from outside our galaxy. Their source is (was) unknown (the recent Auger results are really interesting- the source of cosmic rays and acceleration mechanisms are also a good topic for a talk or final paper). If the energy of a proton gets high enough, it can collide with, and absorb, a photon from the 3-degree microwave background left over from the Big Bang and create an excited state of the proton, which then decays to a proton and a pion, lowering the proton energy substantially and removing it from the spectrum of the highest energy cosmic

rays. The energy of a cosmic microwave background photon is $\sim 26 \times 10^{-5}$ eV; the resonant state of the proton is at 1238 MeV. What is the energy of a cosmic proton that when hitting a cosmic microwave background photon headon will create the resonant state? (An aside: the Delta-1238 state of the proton was discovered by Enrico Fermi at the cyclotron at 5610 S. Ellis Ave. And, the Auger Experiment, initiated by Jim Cronin, has the measurement of this effect, known as the Greisen-Zatsepin-Kuzmin (GZK) Cutoff, as one of its goals.).

6. Perkins Chapter 3, Problem 3
7. Perkins Chapter 3, Problem 5
8. Perkins Chapter 3, Problem 8
9. Perkins Chapter 3, Problem 10