PHYS 200: Problem Set VI

Due: 4:30 pm March 15, 2005

1. [6] At the Brookhaven AGS accelerator, protons of kinetic energy 5.3×10^{-9} J are made to collide with protons at rest.

   (a) What is the speed of one of these moving protons in the laboratory reference frame?

   (b) What is the magnitude of the momentum?

2. [4] A K^0 particle at rest decays spontaneously into a π^+ particle and a π^- particle. What will be the speed of each of the latter? The mass of the K^0 particle is 8.87×10^{-28} kg, and the masses of the π^+ and π^- particles are 2.49×10^{-28} kg each.

3. [3] In modern experimental high-energy physics, energetic particles are made to circulate in opposite directions in so-called storage rings and permitted to collide head-on. In this arrangement each particle has the same kinetic energy KE in the laboratory frame. The collision may be viewed as totally inelastic, in that the rest energy of the two colliding particles, plus all available kinetic energy, can be used to generate new particles and to endow them with kinetic energy. (Notice that when particle physicists speak of the proton energy they are referring to the kinetic energy of the proton.)

   (a) Show that the available energy in this arrangement can be written in the form

   $$E_{\text{new}} = 2mc^2 \left(1 + \frac{KE}{mc^2}\right),$$

   where m is the mass of the colliding particles.

   (b) How much energy is made available when 100 GeV protons are used in this fashion?

   (c) What proton energy would be required to make 100 GeV available?