Space-time and the Quantum World: Week 11

Fall 2008 v2.1

1. Reading:

Styer, *The Strange World of Quantum Mechanics*
Chapters 5 - 10

2. Questions: Due Wednesday November 19, at 5 PM

- Styer: Questions 4.8 - 4.10, 5.1 - 5.8, 5.13, 6.1 - 6.4 (Note the bit on page 10 about the solutions.)
- What is the significance of the magnetic arrow and projection in an in-homogeneous magnetic field? On the basis of this what does the result of the Stern-Gerlach experiment imply about electrons? Is there any way this result could be obtained with compasses? Explain.
- The particle known as K^+ is unstable and decays into two pions

$$K^+ \rightarrow \pi^+ + \pi^0.$$

  The masses of these particles are, for K^+, $M = 0.530$ u, for π^+, $m_+ = 0.150$ u, π^0, $m_0 = 0.145$ u, where $1\text{u} = 1.66 \times 10^{-27}$ kg and $1\text{u}c^2 = 931.5$ MeV ("million electron volts" - a unit of energy). Let's work in the rest frame of the original particle, K^+.

  a. Einstein showed that the change in mass before and after a process is equal to the change in kinetic energy - the meaning of $E = mc^2$. How much kinetic energy is available after this decay? Please state your result in MeV.
  b. Using the proper relativistic conservation laws, write down the conservation of momentum and p^0. You might find it convenient to use the notation $\gamma_+ = 1/\sqrt{1 - \frac{v_+^2}{c^2}}$ for the particle π^+, similarly for γ_0.
  c. After much unpleasant algebra (please don't attempt this, unless you find it amusing!), you obtain the result that

$$m_+\gamma_+ = \frac{M}{2} + \frac{m_+^2 - m_0^2}{2M} \quad (1)$$

$$m_0\gamma_0 = \frac{M}{2} - \frac{m_+^2 - m_0^2}{2M} \quad (2)$$

  Find the two values of γ for each of the particles, π^+ and π_0.
  d. What are the speeds of these particles in this frame? Did we need all that relativity?