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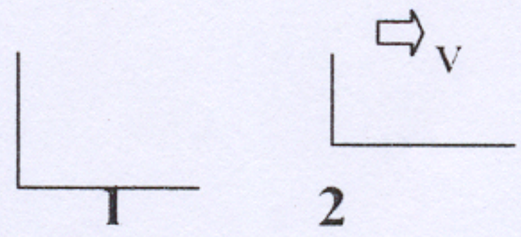
Pratt

Mid Term Exam **Physics IV** 5-3-2004 2pm-4:30 pm

Answer all questions. Maximum marks:80

Useful formulae:



$$x_2 = \gamma (x_1 - v t_1)$$

$$t_2 = \gamma \left(t_1 - \frac{\beta}{c} x_1 \right)$$

$$E = mc^2$$

1. Two neutrons A and B are approaching each other along a common straight line. Each has a constant speed βc as measured in the laboratory. Show that the total energy of B as observed in the rest frame of A is

$$\frac{1+\beta^2}{1-\beta^2} M_0 c^2$$

Where M_0 is the rest mass of the neutron. (β=v/c) (15 marks)

2. Charged Pi-mesons are produced in high energy collisions between protons and neutrons. They decay in their own rest frame according to the law: $N(t)= N_0 (2)^{-t/T}$, where N_0 is the initial number of pi-mesons and T is the half-life= $2X10^{-8}$ Sec. A burst of pi-mesons is produced at the target of an accelerator and it is observed that two-thirds of them survive at a distance of 30metres from the target.
What is the energy of the pi-mesons (expressed in terms of the rest mass energy)? (15 marks)

3. Consider a population of 2-level atoms in thermal equilibrium and bathed in radiation of density ρ_ν where ν is the frequency of radiation. Set up the differential equations for the rate of change of populations of the levels, in terms of the Einstein A and B coefficients, assuming an energy difference in the levels to be $h\nu_0$. Obtain expressions for the coefficients, assuming steady state conditions for the populations. (Explain all the symbols that you may use in the derivation).

Planck's distribution: $\rho(\nu) = \frac{8\pi h\upsilon^3}{c^3} \frac{1}{e^{h\upsilon/kT} - 1}$

(15 marks)

b. Under what conditions of the populations in the two levels does stimulated emission exceed absorption? (5 marks)

c. Sketch (approximate shape) the Planck distribution function and show that there is a frequency where the radiation density is a maximum. (5 marks)

4. Write a brief essay (about 250-300 words) on the wave-particle duality choosing any two of the experiments discussed in class, to illustrate the particle nature of waves and the wave nature of particles. Use appropriate equations to illustrate your essay. (25 marks)