

## Exercises for "Phenomenology of Particle Physics I"

Prof. Dr. A. Gehrman	sheet 1	handed out:	23.9.2008	
M. Ritzmann		handed in:	30.9.2008	
<a href="http://www.itp.phys.ethz.ch/education/lectures_hs08/PPPI">http://www.itp.phys.ethz.ch/education/lectures_hs08/PPPI</a>			returned:	7.10.2008

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### Exercise 1

Discuss the use of "natural units":

- (i) Find the connection between energy (GeV) and time (sec), length (cm) and gramme (g).
- (ii) Calculate the ratio  $a_{\text{Bohr}} : \lambda_{\text{Compton}} : r_0$  for an electron in "natural units" (in cgs units:  $a_{\text{Bohr}} = \hbar^2/m_e e^2$ ,  $\lambda_{\text{Compton}} = \hbar/m_e c$ ,  $r_0 = \alpha \hbar/m_e c$ , "classical" electron radius,  $\alpha = e^2/\hbar c$ ).
- (iii) Often one does also set  $k_B = 1$  ( $k_B$  is the Boltzmann constant). What is the relation between temperature (K) and energy (GeV)?

### Exercise 2

A photon  $\gamma$  ( $k^2 = 0$ ) with four-momentum  $k^\mu = (E, E, 0, 0)$  is scattered off an electron  $e$  at rest ( $p_e^\mu = (m_e, 0, 0, 0)$ ). After the scattering the  $\gamma$  has the four-momentum  $k'^\mu = (E', E' \cos \Theta, E' \sin \Theta, 0)$ . Show that the energy  $E'$  after the scattering is given by

$$E' = \frac{E}{1 + \frac{E}{m_e}(1 - \cos \Theta)}$$