1. Übungsblatt zur Vorlesung — WS 2019/20

Einführung in die Elementarteilchentheorie — **Prof. G. Hiller**
Abgabe: bis Di. 15. Oktober 2019, 12:00 Uhr — **Kasten 245**

http://people.het.physik.tu-dortmund.de/~ghiller/WS1920ETT.html

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Exercise 1: Kinematics **(5 Points)**

Two protons collide and produce a third particle χ with the mass M:

$$p + p \to \chi + p + p \tag{1}$$

(a) Compute the energy limit of the colliding protons in the center of mass system (CMS), which allows the reaction kinematically.

(b) Use your result to compute the minimal momentum in the laboratory frame of reference (one of the initial protons is at rest).

Exercise 2: Kinematics with Lorentz mathematics **(5 Points)**

Decide, if the following processes are kinematically allowed. Justify your answers with four-momenta calculations.

(a) A photon collides with an electron and gets absorbed.

(b) A photon decays into a pair of $\mu^+\mu^-$.

(c) A moving positron and an electron at rest annihilate into one photon.

(d) A Higgs boson decays into a pair of a top and anti-top quark.

Exercise 3: Even more kinematics **(5 Points)**

Consider a photon with four-momentum $k^\mu = (E, 0, 0, E)$ and $k^2 = 0$ scattering off of an electron with mass m_e at rest. After the scattering process, the four-momentum of the photon is given by $k'^\mu = (E', E'\sin\theta, 0, E'\cos\theta)$, where θ is the scattering angle. Show that the energy of the photon in the final state is given by

$$E' = \frac{E}{1 + \frac{E}{m_e}(1 - \cos\theta)}. \tag{2}$$

Exercise 4: Crazy decays **(5 Points)**

Why is it not possible to observe the following processes in nature? If there is more than one reason write down all of them. In the following, X denotes a nucleus.

(a) $p \to e^- + \pi^0$,

(b) $\mu^- \to \tau^- + \gamma$,

(c) ${}^A_Z X \to {}^A_{Z+2} X + e^- + e^-$,

(d) $h^0 \to t\bar{t}$.