Particle Physics
Relativistic Kinematics

Exercises

1. Prove that the squares of four-vectors are relativistically invariant!   **[2]**

2. Prove that the products of four-vectors are relativistically invariant!   **[2]**

3. Show that the square of the four-velocity is equal 1!   **[2]**

4. An electron and a proton have the same curvature in a magnetic field.
The electron moves twice as fast as the proton.
What is the momentum of both particles?   **[2]**

5. The IceCube experiment measures interactions of high energetic cosmic neutrinos in 1 km^3 of Antarctic ice. Cosmic τ neutrinos produce τ leptons with a mass of 1.78 GeV and a proper lifetime of 0.3 ps. What is the decay length of a τ lepton with an energy of 356 TeV?   **[2]**

6. In 1987 the supernova SN1987A exploded at a distance of 168.000 light years. Assume it simultaneously emitted photons and neutrinos with a momentum of 9 MeV.
- Calculate the relation between the neutrino mass and the time difference of the arrival of the photons and neutrinos on Earth!   **(3)**

7. In the Large Hadron Collider LHC at CERN in Geneva protons are accelerated to 7 TeV and brought to collision. To which energy should one accelerate a proton beam in order to reach the same reaction energy on a proton at rest?   **[3]**