

Tutorial “General Relativity”

Winter term 2014/2015

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Sheet No. 1

will be discussed at: 04.11.2014

1. Decay of the muon

Muons were discovered while studying cosmic radiation at Caltech in the thirties of the last century. The muon is an unstable subatomic particle with a mean life time of $\tau \sim 2.2\mu s$. Their decay via the weak interaction is described by

$$N(t) = N_0 e^{-\frac{t}{\tau}},$$

where $N(t)$ is the quantity of muons after the time t and N_0 is the primary quantity. They travel nearly with speed of light $0.998c$ while produced.

- What distance can a muon manage in its proper time¹?
- Why does an observer on the earth measure a mean lifetime of around $31\mu s$. What distance would a muon travel in this time?
- Suppose, that in 9 kilometers above sea level 10^8 muons were produced. How many of them reach the earth's surface (non-relativistically)? Why does an observer detect nearly 99% of them nonetheless?

2. Addition of velocities

Given a particle in frame Σ , which is moving at $\vec{u} = \frac{3}{4}c$ to the right and another observer in frame Σ' , which is moving with $\vec{v} = \frac{3}{4}c$ to the left. Why does the observer in Σ' not measure a total speed of $\frac{3}{2}c$ of the particle. What speed does he measure?

3. Arrow

An one Meter long arrow has been shot. While passing your view, you measure a length of 86.6 cm. At what speed \vec{v} travels the arrow.

4. Speed of a particle

If a particle's kinetic energy is n times its rest energy, what is its speed?

5. Lorentz invariance

Which of the following quantities is Lorentz-invariant?

- a.) \vec{x}^2 b.) $x_\mu x^\mu$ c.) $x^\mu x^\nu$ d.) $\eta_{\mu\nu}$ e.) ds^2 f.) $(dx^0)^2$ g.) γ

¹Eigenzeit