Übungen zur Vorlesung "Feldtheorie"

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Prof. Dr. K.-H. Rehren
Dr. Julien Queva
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Problem 1 Consider a (inertial) frame of reference in which there is an homogeneous electric field $\vec{E}$, and $\vec{B} = 0$. Consider a second frame related to the former by a velocity $\vec{v}$ orthogonal to $\vec{E}$.

a) Write the electric and magnetic field $\vec{E}'$ and $\vec{B}'$ as perceived in this frame.

b) In the second frame consider a charged particle moving at constant velocity $\vec{w}$ such that the force $\vec{F}'$ exerted on the particle is null. Find $\vec{w}$, conclude.

Problem 2 The geodesics on a sphere

The length of a curve C on the surface of a sphere is

$$\ell = \int_C \sqrt{R^2(\dot{\theta}^2 + \sin^2(\theta)\,\dot{\varphi}^2)}\mathrm{d}t$$

a) Find the Euler-Lagrange equations for the geodesics (curves of smallest length).

b) Eliminate the parameters t using $\partial_t = \dot{\varphi}\partial_\varphi$ to rewrite them as a differential equation for $\theta(\varphi)$.

Problem 3 *(metric and potentials)*

a) Compute the Euler-Lagrange equations for

$$L = -mc\sqrt{g(\vec{x})(\partial_\tau x^0)^2 - |\partial_\tau \vec{x}|^2}$$

b) Show that the resulting equation of motion is equivalent to the one obtained for

$$L' = -mc^2\sqrt{g(\vec{x}) - c^{-2}\,|\dot{\vec{x}}|^2}$$

c) Then let $g(\vec{x}) = 1 + \frac{2V(\vec{x})}{mc^2}$, where $V(\vec{x}) \ll mc^2$, and study the approximations when $|\dot{\vec{x}}|^2 \ll c^2$ or when $|\dot{\vec{x}}|^2/c^2$ may be large.