Exercises on General Relativity TVI TMP-TC1
Problem set 2, due November 6th

Exercise 1 – Mass dimensions in classical electrodynamics

Write down the Maxwellian action functional (classical electrodynamics) in D space-time dimensions in terms of the vector field A^μ and the current J^μ (always work in natural units).
What is the energy/mass dimension of the following objects: ∂_μ, A_μ, $F_{\mu\nu}$ and J_μ ?

Exercise 2 – EMT Self-Coupling

Given the following Lagrange density of a free massless scalar field:

$$\mathcal{L} = -\frac{1}{2}\partial_\mu\phi\partial^\mu\phi \tag{1}$$

Take this theory and introduce self-coupling by adding the following interaction term:

$$\mathcal{L}_I = g\phi\,\mathrm{tr}_\eta(T), \tag{2}$$

where g is a dimensionless coupling constant and T the energy momentum tensor (EMT) of $\mathcal{L}$. Derive the new energy momentum tensor T_I of the theory $\mathcal{L} + \mathcal{L}_I$. Now repeat this procedure defining the second interaction term as

$$\mathcal{L}_{II} = g\phi\,\mathrm{tr}_\eta(T_I)\,. \tag{3}$$

Discuss the conditions that need to hold for the coupling constant g for such an iteration to be feasable.

Exercise 3 – Fermions

Discuss whether fermions are a good candidate for mediating gravity.

Exercise 4 – Integral of the Sinc Function

In the lecture you encountered the integral

$$I = \int_{\mathbb{R}} dx \frac{\sin(x)}{x}.$$

Evaluate this integral, using complex analysis.

General information

The lecture takes place on Monday at 14:00-16:00 and on Friday at 10:00 - 12:00 in A348 (Theresienstraße 37).

Presentation of solutions:
Monday at 16:00 - 18:00 in B 138

There are six tutorials:
Monday at 12:00 - 14:00 in A 249
Thursday at 16:00 - 18:00 in A 449
Friday at 14:00 - 16:00 in B 139, C 113 and A 249
Friday at 16:00 - 18:00 in A 249

The webpage for the lecture and exercises can be found at

www.physik.uni-muenchen.de/lehre/vorlesungen/wise_17_18/tvi_tc1_gr/index.html