FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

Gravitational action, boundary terms, and black hole thermodynamics

1 What to expect

You will be asked one theoretical and one computational question out of the following two sets. You will have 30 minutes to prepare your answers. After that, we will discuss your answers and some (un)related problems. The discussion should last about 30 minutes, including my feedback to you.

2 Computational questions

1) How do we describe matter in curved spacetime via Lagrangian formalism? Derive the corresponding field equations. I may ask you to do this concretely for a given matter Lagrangian.

2) Define first and second fundamental forms. I may ask you to calculate these for simple examples, such as sphere, cylinder, or a boundary of flat or Schwarzschild metrics. What about the intrinsic point of view?

3) By employing the Euclidean trick, derive the Hawking temperature of a simple spherically symmetric spacetime of my choice. How is the free energy related to the gravitational Euclidean action?

3 Theoretical questions

1) Define the Rosenfeld's energy momentum tensor and discuss its basic properties. When and why is it conserved? I may ask you to calculate it concretely for a very simple field content.

2) Derive (similar to what was done in the lecture) the Einstein equations from an action principle (using action and formalism of your preference). Can we write another geometrical gravity theory in 4 dimensions?

3) Why do we 'upgrade' the Einstein-Hilbert action by York and Gibbons-Hawking terms? Write down the total gravitational action, and identify its contributions.

4) Write down the first law of black hole thermodynamics. Identify various terms. What does it describe and how can we 'derive' it?