

General relativity: Questions for oral examination

The oral examination will take around 30 minutes. The starting point will be one or two of the following questions. This will be followed by some follow-up questions, and a discussion of related concepts. When passed, 40% of the final grade will come from the result of the oral examination.

1. Explain the equivalence principle, and use it to argue that gravity must be described as an expression of spacetime curvature, rather than as a force.
2. What is a geodesic? There are two definitions. State and explain both of them, in mathematical terms as well as in words.
3. Spacetime curvature is described by the Riemann tensor. Explain two different geometrical ways in which curvature shows up, and how these can be expressed by means of the Riemann tensor.
4. The causal structure of spacetimes can be visualized using Penrose diagrams. Explain what a Penrose diagram is in general, provide two examples of such diagrams, and explain what can be read off from them.
5. The predictions of General Relativity concerning properties of orbits around a star or a black hole differ in some respects from the Newtonian predictions. Explain in what ways, and compare the effective potentials of the two theories.
6. What experimental evidence is there for General Relativity? Imagine that you are trying to convince someone who doesn't believe in the theory, that it is necessary to account for experimental and observational data.
7. Write down the line element for a general Robertson-Walker-cosmology. Explain the assumptions behind it. Discuss qualitatively what conclusions that can be drawn, when this line element is inserted into Einsteins equations for the case of a dust-filled universe.
8. There is a surprising correspondence between black hole physics and thermodynamics. Explain this correspondence in broad terms, as well as its connection to the so called information paradox.