SH2374 General Relativity 7.5 credits

Allmän relativitetsteori

This is a translation of the Swedish, legally binding, course syllabus.

Establishment

The course plan applies from HT2025 according to faculty board decision: S-2024-0066. Decision date: 2024-10-07

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Engineering Physics

Specific prerequisites

English B/English 6

SH2373 Special Relativity and good knowledge of multivariable calculus. However, SH2373 can be studied in parallel.

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

After passing the course, the student should be able to:

- Use differential geometry to describe the properties of a curved space and compute basic quantities in differential geometry. Explain and interpret transformation properties of tensors.
- Use the Schwarzschild solution to Einstein's field equations in vacuum and explain and interpret it in different coordinates.
- Derive and use Einstein's field equations and describe the definition and role of the energy-momentum tensor in those, explain the physical interpretation of its components, and prove that Newton's theory of gravity is recovered in the non-relativistic limit.
- Calculate physical quantities for test particles in a given solution to Einstein's field equations, for example, particle trajectories and proper times.
- Describe the experiments with which the general theory of relativity has been tested and compare with predictions from Newton's theory of gravity.
- Use the Friedmann–Lemaître–Robertson–Walker metric to describe the different possibilities for how a homogeneous universe evolves in time and describe the ideas behind cosmological inflation and dark energy.

Course contents

- Basic differential geometry: Manifolds. Local coordinates on manifolds. Covariant and contravariant vectors and tensors. Transformation properties of tensors. Vector fields. (Pseudo)-Riemannian metric. Covariant derivatives (Christoffel symbols and Levi-Civita connection). Parallel transport and geodesics. Curved spaces. Lie derivatives and Killing vector fields.
- General theory of relativity: Basic concepts and principles in general relativity. Rindler coordinates. The Schwarzschild solution. Eddington–Finkelstein coordinates. Kruskal–Szekeres coordinates. Einstein's field equations. The Einstein–Hilbert action. The energy-momentum tensor. The weak field approximation. Experimental tests of general relativity. Gravitational lensing. Gravitational waves. Introductory cosmology (including the Friedmann–Lemaître–Robertson–Walker metric), including inflation.

Examination

- TEN1 - Examination, 7.5 credits, grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH’s coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

If the course is discontinued, students may request to be examined during the following two academic years.

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.