

Origin, structure, and evolution of the Universe

Lecturer: Yuri Levin, yuri@strw.leidenuniv.nl, www.strw.leidenuniv.nl/yuri, 459 Oort building.

Textbooks:

Cosmology: The Origin and Evolution of Cosmic Structure, by Coles and Luccin, Second Edition. This textbook is required.

Also recommended for the relativity part:

Spacetime and Geometry, by Sean Carroll, and

Applications of Classical Physics, by Blandford and Thorne. Available online at <http://www.pma.caltech.edu/Courses/ph136/yr2004/>, Chapter 1, 23-27

Lectures: 15:45–17:30, HL427

Wednesdays: Sep 2, 9, 16, 30; Oct 7, 28; Nov 4, 11, 18, 25; Dec 2

Tuesdays: Sep 8, 15, 29; Oct 6

Office hours: Friday 9:30—11:30

Assessment: Approximately weekly assignments, typically given out on a Wednesday (by posting on www.strw.leidenuniv.nl/yuri) to be handed in the following Wednesday in the beginning of the lecture. You are allowed to exchange ideas on how to solve the problems, but you are not allowed to copy other students' solutions. If you have a good reason to be late with submitting your solutions, you must get a prior permission from me or from the Teaching Assistant, otherwise your grade may be reduced.

The last assignment will be a take-home exam. It will count 30% of the total grade and will cover a selection of topics from the whole course. It must be completed without any consultation with others, but the use of books or other reference materials is allowed.

Teaching Assistant: Alizera Rahmati, rahmati@strw.leidenuniv.nl, room 553, office hours Monday 1–3.

Approximate Contents:

1. Cultural introduction to General Relativity

- a. Vectors and tensors. Lorentz transformation.
- b. Metric tensor and connection coefficients
- c. Particle and photon motion in curved spacetime
- d. Riemann, Ricci, and Einstein tensors.
- e. Stress-energy tensor
- f. Einstein equations

2. Friedman Equations

- a. Friedman-Robertson-Walker metric. Closed, open, and flat Universes.
- b. Equation of state: radiation, matter, and vacuum
- c. Friedman equations and basic solutions
- d. Hubble flow

3. Dark energy

- a. Cosmography and standard candles

- b. Bayesian formalism for statistical inference
 - c. Evidence for dark energy from type-Ia supernovae
 - d. Theoretical ideas
- 4. Inflation and topological defects**
- a. Cultural introduction to scalar fields.
 - b. Phase transitions and topological defects
 - c. Horizon, flatness, and monopole problems
 - d. Inflationary solutions
 - e. Inflationary theory
- 5. Thermal history of the Early Universe**
- a. Early phase transitions
 - b. Nucleosynthesis
 - c. Recombination and photon decoupling
- 6. Cosmology from cosmic microwave background**
- a. Physics of acoustic waves. Two-fluid formalism. Silk damping.
 - b. Sachs-Wolfe effect. Acoustic peaks.
 - c. Spectrum of CMBR perturbations
 - d. Observations: WMAP and balloon experiments.
 - e. Λ -CDM paradigm
- 7. Structure formation**
- a. Linear theory. Growth of super/sub-horizon perturbations
 - b. Power spectrum and filters. Harrison-Zeldovich spectrum.
 - c. Non-linear theory. Pancakes. Press-Shechter formalism.
 - d. Cosmic web: observational appearance of the Large-Scale Structure.
 - e. Cosmic web: N-body simulations.
 - f. Gas dynamics
- 8. Concordance Cosmology**
- 9. Open questions**