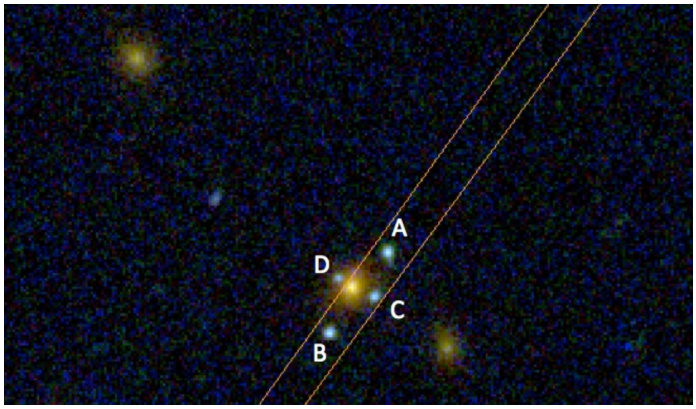
Gravitation and Cosmology



Einstein cross:
a strong gravitational lensing effect
(D. Bettoni et al,
arXiv:1902.10964v1)

Teachers: **B. Chauvineau, E. Slezak**

Supervisor: **B. Chauvineau**

Contact

✉ chauvineau@oca.eu

Objectives

The main aims of these lectures are:

1. to provide the basic knowledge and skills in General Relativity (GR), including its mathematical foundations and tools, since this theory is more and more widely used in modern astrophysics, especially in cosmology;
2. to provide attendees with the fundamental concepts underlying the application of GR to the Universe as a whole and an in-depth description of the standard cosmological model for an homogenous universe and of the time evolution of its main parameters.

Evaluation

A written exam (4/5 of the global mark -50/50 GR/Cosmology-) and a TPE like work on cosmology (1/5 of the global mark).

For the TPE part, attendees will be asked to provide a small report based on recent scientific papers on how the value of Hubble parameter can be obtained from observational data (cf. cosmic distance ladder), on pros and cons of each indicator, and on possible tensions between the various measured values w.r.t. biases.

Main progression steps

- First 3 or 4 lectures on gravitation, Riemannian geometry, tensorial calculous and GR.
- Following lectures are a mix of cosmology and gravitation/mathematics/GR.
- The TPE is an autonomous work. It may start before the end of the lecture sessions (end of February) and has to be finished by the end of April. This work, which has to be mostly conducted in parallel to the METEOR spring session, will benefit from remote assistance all along this period if requested and of a dedicated 2h session with the teacher to solve problems if any. During the final 2h session at the end of April, each group of students will present the knowledge they acquired this way as a mini-lesson for the other students and answer questions.

Bibliography & Resources

http://mauca.unice.fr/index.php/documents-for-fc2-5-general-relativity-extragalactics-and-cosmology/

Contents

General Relativity

by B. CHAUVINEAU

1. Newton's spacetime and the MM experiment
2. Minkowski's spacetime
3. Spacetime, inertia and gravitation
4. Riemannian geometry and tensorial calculous: and introduction
   (a) Tensorial calculous
   (b) Geodesics
   (c) Curvature tensors
5. General Relativity
   (a) Einstein's field equation
   (b) The cosmological constant versus fundamental physics
6. Solving the Einstein equation (some solutions in brief)
   (a) Some exact solutions (Schwarzschild, ...)
   (b) Approximate methods (in brief): linearized equations

Cosmology

by E. SLEZAK

1. Fundamentals Concepts
   (a) the cosmological principle
   (b) a relativistic science
2. The Standard Cosmological Model
   (a) general relativity and Riemaniann spaces
   (b) the Robertson-Walker metric
   (c) the Einstein equations and the Friedmann homogeneous models
   (d) dynamics of the Universe : cosmic time, thermal history of the Universe
3. Distances
   (a) Mattig formula
   (b) distance estimates
4. The concordance model