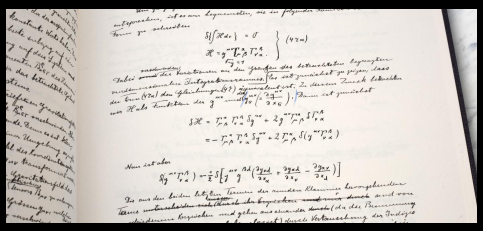
Relativistic Gravitation and Astrophysics



Geometric gravity theories (General Relativity and alternatives) ...
their tools and methods ...
their applications to astrophysics and cosmology.

OBJECTIVES

Improving your knowledge in relativity and in some related astrophysical applications.

It mainly consists in the acquisition of the skills required in geometric gravity and relativistic astrophysics. This includes mastering the mathematical tools required to be conversant in these fields. Special attention will be payed to exact solutions in General Relativity (GR).

PREREQUISITES

The GR lectures of the fundamental courses. (It is of first importance the student not to be scared by the formal issues involved in this course.)

THEORY

by Bertrand CHAUVINEAU

- Mathematics

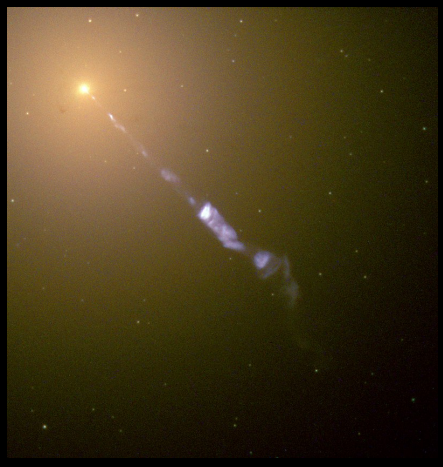
Tensorial calculous
Curvature
Geodesic curves
More advanced topics

- Gravitation theories

GR, scalar-tensors gravity and various alternative theories
Lagrangian formalism
Matter description, stress tensor
Some exact solutions: Schwarzschild, Robertson-Walker, Kasner, axial symmetry, Kerr,...
Linearized theory
Gravitational waves
Conservation laws in GR

- Relativistic Astrophysics

Perfect fluids in astrophysics
Black holes' environment
Gravitational radiation
Backgrounds on cosmology



APPLICATIONS

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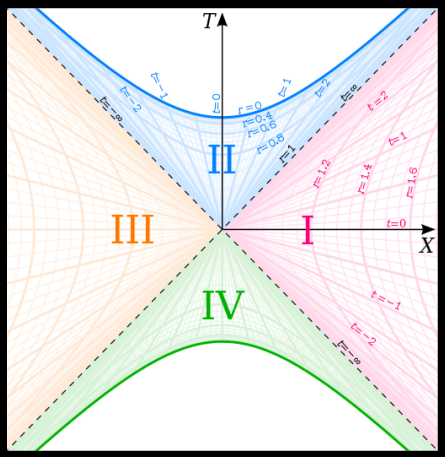
The student will choose a part of the lectures, or a specific topic related to them, and make a presentation that shows his mastering of its different aspects, including technical issues.

MAIN PROGRESSION STEPS

- Whole period: theoretical courses and exercises (about 60h, planified on 3/4 sessions a week).
- Whole period: reading of some review and pedagogical papers.
- Last 2 weeks: focus on a specific topic and preparation of the oral presentation.



EVALUATION

- (1) A written exam, followed by a direct discussion on the "hard points", to estimate how the student reacts when guided.
- (2) The student's investment during the whole period is evaluated too.

The weights of these two marks ((1) and (2)) are 3/5 and 2/5 respectively.

BIBLIOGRAPHY & RESSOURCES

Any book (or online courses) in GR designed for undergraduate and/or graduate students is welcome.

More specifically, let me suggest (plenty of books ... hard to choose!):

- C.W. Misner, K.S. Thorne, J.A. Wheeler, *Gravitation*, (San Francisco, Freeman, 1973).
  THE reference in the field, even if a bit old. Different levels of reading. An about 1000 pages book!
- R.M. Wald, *General Relativity*, (The University of Chicago Press, 1984).
  In two parts: 1. Fundamentals (about 150 pages), 2. advanced topics (about 300 pages).
- H. Stephani, *General Relativity*, (Cambridge University Press).
  Different editions. I like the second one (1990).
- L. Landau, E. Lifchitz, *Field theory*, (Mir Editions, 1970).
  Of course, the 2d volume of their renowned course of physics! The second part is devoted to general relativity.

Let me also mention two recent french books, that are mainly compilations of exercises, with corrections:

- D. Gialis, F.-X. Désert, *Relativité Générale et Astrophysique*, (EDP Sciences, 2015).
- A. Barrau, J. Grain, *Relativité Générale*, (Dunod, 2016).

CONTACT

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