PHYS 5500, Section 1
Astrophysics, Cosmology and Gravitational Waves

One-credit course

Syllabus - Fall 2017

Instructor
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Course description

These are exciting times in our quest towards understating the large-scale structure of the universe. Outstanding open problems meet increasingly more precise observational methods. Perhaps contrary to intuition, the expansion of the universe is accelerating rather than slowing down, an observation that was awarded the Nobel Prize in 2011. Only last year, exactly one hundred years after Einstein wrote down his famous equations, gravitational waves were discovered by Laser Interferometer Gravitational-Wave Observatory (LIGO).

In this course, we will review the basic formulation of Einstein's equations of General Relativity and apply them to topics of current interest in astrophysics, cosmology and gravitational wave astronomy.

Approach

The course will be based on a combination of white board talks with a strong emphasis on `hands-on activities'. By hands-on activities it is meant the resolution of practical problems on the computer. Wolfram Mathematica software (no campus license needed) will be used for that purpose.

Goals

By the end of the course, students will:

- have gained familiarity with the formation and evolution of planets, stars, and galaxies, the thermal history of the Universe and major cosmological models,
- have a basic understanding of gravitational waves and observational methods in astrophysics and,
- be able to solve problems employing Wolfram Mathematica language, which is currently considered a computing standard in college education and physics research.

Topics covered

Topics in three interrelated areas, astrophysics, cosmology and gravitational wave physics, will be covered in the course:

Astrophysics

- Stellar structure and evolution
- Galaxies and the Milky Way
- The Structure of the universe

Cosmology

- The expansion of the universe
- The cosmic microwave radiation background
- The early universe and inflation

Gravitational waves (GWs)

- Introduction to GWs and linearisation of Einstein's equations.
- Leading order generation of GWs, quadrupole formula.
- GWs from binary systems on inspiraling, circular orbits.

Prerequisites

Classical field theory and Modern Physics (Phys 2710 or 3710) at undergraduate level is desirable but not necessary. No prior knowledge of Wolfram Mathematica programming is required.

Text

The course will utilize the instructors' own lecture notes based on the following textbooks:

- Carroll, B.W. & Ostlie, D.A., *An Introduction to Modern Astrophysics* (Pearson)
- S. Weinberg, *Cosmology*, Oxford University Press (2008).
- M. Maggiore, *Gravitational waves, volume 1: theory and experiments*, Oxford University Press (2008).

Grading

Grades will be based on a final project.