Astrophysics of compact objects - course description

General information

Course name	Astrophysics of compact objects
Course ID	13.7-WF-FizD-ACO-S19
Faculty	Faculty of Physics and Astronomy
Field of study	Physics
Education profile	academic
Level of studies	Second-cycle studies leading to MS degree
Beginning semester	winter term 2020/2021

Course information

Semester	4
ECTS credits to win	6
Available in specialities	Astrofizyka komputerowa
Course type	obligatory
Teaching language	english
Author of syllabus	• dr hab. Dorota Rosińska

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	15	1	-	-	Exam
Class	30	2	-	-	Credit with grade

Aim of the course

Deep knowledge in the field of astrophysics of compacts objects. Solving problems in the field of compact physics using elements of general relativity.

Prerequisites

Basic knowledge of properties of compact objects, of quantum physics and of general relativity. Knowledge of differential calculus. Ability to program and use numerical methods.

Scope

- Equation of state and structure of white dwarfs and neutron stars.
- Non-rotating models of neutron stars.
- Stability of neutron stars and white dwarfs.
- Schwarzschild solution and properties of spherically symmetric black holes.
- Kerr black holes.
- Properties of rotating neutron stars.
- Criteria for the stability of rigidly rotating relativistic stars.
- Astrophysics of compact binaries.
- Compact objects as sources of gravitational waves.

Teaching methods

Conventional lecture, class with calculating exercises and project

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
A student is able to characterize the final stages of stellar evolution: white dwarfs, neutron stars and black holes. Can describe the basic differences between stars and compact objects. A student has knowledge of equations of state of dense matter. Understands and describes the processes occurring in the interior of neutron stars and white dwarfs. A student is able to construct numerical models of non-rotating white dwarfs and neutron stars, and understands the reasons for the existence of the upper limit on their gravitational mass. Can describe the effect of rotation (rigid, differential) on the global parameters of neutron stars. Can provide the stability criteria for non-rotating and rotating relativistic stars. Can name and describe the most important relativistic effects associated with compact objects. Has knowledge of astrophysical phenomena occurring in binary systems containing a compact object. Has a basic knowledge of properties of black holes. Can describe mechanisms of emission of gravitational radiation from compact object binaries, or rotating neutron stars.	• K2_W03 • K2_W04 • K2_W06 • K2_U01 • K2_K01 • K2_K02	• a discussion • an exam - oral, descriptive, test and other	• Lecture

Outcome description	Outcome symbols	Methods of verification	The class form
Students can write numerical codes (construct algorithms or adopt available numerical libraries) to solve basic problems arising in astrophysics of compact objects. In particular to integrate the equations of the stellar structure of relativistic stars (Oppenheimer-Volkoff equations) to obtain their gravitational mass and radius for a given equation of state. A student understands the need for further training and is able to understand the lectures of specialists in the field of relativistic astrophysics Can analyse astrophysical problems and formulate questions to have deeper understanding of a topic. A student is able to search for information in english literature.	• K2_W04 • K2_W05 • K2_U01 • K2_U02 • K2_U03 • K2_U05	• a discussion • a project • a written statement • an evaluation test • an ongoing monitoring during classes • an oral response	• Class

Assignment conditions

Lecture: Positive passing of final exam

Class: Handing in homework exercises, oral presentations, passing a written test, a project - writing a program to calculate properties of compact objects. Positive marks of all activities.

Final grade: weighted average of the exam and class (50% and 50% respectively)

Recommended reading

[1] S. Shapiro, S. Teukolsky, Black Holes, *White Dwarfs and Neutron Stars,* Wiley-VCH 2004.

[2] M. Demiański, *Astrofizyka relatywistyczna*, PWN.

[3] P. Haensel, A. Y. Potekhin, D. G. Yakovlev, *Neutron Stars*, Springer 2007.

[4] James B. Hartle*, Grawitacja*, 2009, ISBN 9788323504764.

Further reading

[1] C. W. Misner,K. S. Thorne, J. A. Wheeler, *Gravitation*, 1973.

[2] M. Camenzind, *Compact objects in astrophysics*, Springer, 2007.

[3] W. H. G. Lewin, M. van der Klis, *Compact Stellar X-ray Sources*, Cambridge Uni. Press, 2006.

Notes

Modified by dr hab. Piotr Lubiński, prof. UZ (last modification: 09-06-2020 22:59)