Wrocław University of Science and Technology
Doctoral School

# COURSE CARD

## 1. Basic information

| | | |
|---|---|---|
| Course name in English: | Advanced topics of astrophysics | |
| Course name in Polish: | Zaawansowane tematy z astrofizyki | |
| Number of hours: | 30 | |
| Type of course: | Elective course | |
| Form of course: | mixed forms (combination of lecture and seminar with computational exercises) | |
| Code of course: | | |
| Course leader: | dr hab. Bert Tobias Fischer, Prof. PWr | |
| Faculty of the course leader: | W11 Faculty of Fundamental Problems of Technology | |
| Email address of the course leader: | bert-tobias.fischer@pwr.edu.pl | |
| Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course): | Architecture and urban planning | ☐ |
| | Automation, electronic, electrical engineering and space technologies | ☒ |
| | Information and communication technology | ☐ |
| | Biomedical engineering | ☐ |
| | Chemical engineering | ☐ |
| | Civil engineering, geodesy and transport | ☐ |
| | Materials engineering | ☐ |
| | Mechanical engineering | ☐ |
| | Environmental engineering, mining, and energy | ☐ |
| | Mathematics | ☒ |
| | Chemical sciences | ☐ |
| | Physical sciences | ☒ |
| | Management and quality studies | ☐ |

## 2. Objectives

C1. Students will gain basic knowledge of astronomical objects and selected high-energy astrophysical processes.

C2. Students will gain skills in using basic calculus techniques for analytical solutions of simple astrophysical problems.

C3. The lecture will cover selected areas of contemporary research in stellar astrophysics.

C4. Students will be able to engage in current research related to the lecture topic.

## 3. Content

*Detailed information about the course content, including topics and form of classes.*

| No. | Topic | Number of hours | Form of classes |
|---|---|---|---|
| 1 | Introduction; revisiting concepts of general relativity | 4 | lecture |
| 2 | Equation of state in astrophysics | 4 | lecture |
| 3 | Big bang | 2 | lecture |
| 4 | Non-degenerate astrophysical objects; galaxies, stars, planets | 4 | lecture |
| 5 | Concept of hydrostatic equilibrium and degenerate astrophysical objects; white dwarfs, neutron stars | 4 | lecture |
| 6 | Transport theory and applications | 6 | lecture |
| 7 | Gravitational waves | 6 | lecture |

## 4. Prerequisites

*List of prerequisites relating to knowledge, skills and other competences for course participants.*

1. Standard theoretical physics knowledge (classical mechanics, electromagnetism, quantum mechanics, statistical physics and thermodynamics).

2. Mathematical foundation for general relativity; differential geometry (advantages but not absolutely necessary).

3. At least one programming language for the computational exercises.

3. Basic English language.

## 5. Learning outcomes

*List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).*

| **Symbol** | **Learning outcome** | |
|---|---|---|
| | *KNOWLEDGE. Doctoral student knows and understands:* | |
| SzD_W3 | the main trends in the development of the scientific or artistic disciplines covered in the curricula; | ☐ |
| SzD_W4 | research methodology; | ☒ |
| SzD_W5 | the rules for the dissemination of scientific results, including in open access mode; | ☐ |
| SzD_W6 | the fundamental dilemmas of modern civilization; | ☐ |
| SzD_W7 | the legal and ethical conditions of scientific activity; | ☐ |
| SzD_W8 | the economic and other relevant conditions of scientific activity; | ☐ |
| SzD_W9 | basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results. | ☐ |

| | | |
|---|---|---|
| | *SKILLS. Doctoral student is able to:* | |
| SzD_U2 | use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular:<br>- define the purpose and subject of scientific research, formulate a research hypothesis,<br>- develop research methods, techniques and tools, and use them creatively,<br>- draw conclusions on the basis of scientific research;<br>critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development;<br>transfer the results of scientific activities to the economic and social spheres; | ☒ |
| SzD_U3 | communicate on specialised topics to the extent that they enable an active participation in the international scientific community; | ☐ |
| SzD_U4 | disseminate research results, including in popular forms; | ☐ |
| SzD_U5 | initiate debates and participate in a scientific discourse; | ☐ |
| SzD_U6 | be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment; | ☐ |
| SzD_U7 | plan and implement an individual or collective research or creative activity, including in an international environment; | ☐ |
| SzD_U8 | independently plan and act for one's own development and inspire and organize the development of others; | ☐ |
| SzD_U9 | plan classes or groups of classes and implement them using modern methods and tools. | ☐ |
| | *SOCIAL COMPETENCES. Doctoral student is ready to:* | |
| SzD_K3 | fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way; | ☐ |
| SzD_K4 | maintaining and developing the ethos of research and creative environments, including:<br>- carrying out scientific activities in an independent manner,<br>- respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection. | ☒ |

## 6. Evaluation

*Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.*

Examination (written), discussions during the lecture, activity during the lecture

## 7. Teaching methods

*Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.*

N1. Lecture

N2. Exercise sessions incl. computational exercises (optional but useful for exam)

## 8. Literature

*List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.*

[1] "Theoretical Astrophysics" by T. Padmanabhan, Vol.I–III (Cambridge University Press)

[2] „Black Holes, White Dwarfs, and Neutron Stars – The Physics of Compact Objects" (WILEY-VCH Verlag GmbH & Co. KgaA) by S.L.Shapiro & S.A.Teukolsky

[3] „An Introduction to Modern Astrophysics" (2nd edition) by B.W.Carroll & D.A.Ostile

[4] „The Relativistic Boltzmann Equation: Theory and Applications" (Progress in mathematical physics ; Vol. 22) by Cario Cercignani & Gilberto Medeiros Kremer, ˝ 2002 Springer Basel AG, Originally published by Birkhaeuser Verlag Basel in 2002

## 9. Other remarks

*Additional remarks, comments, (e.g., language of the course)*

English