

## Subject card

|                                             |                                                                                                                                                                                                                                                                                               |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-----|
| Subject name and code                       | Astrophysics, PG_00182265                                                                                                                                                                                                                                                                     |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
| Field of study                              | Physics                                                                                                                                                                                                                                                                                       |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
| Date of commencement of studies             | October 2025                                                                                                                                                                                                                                                                                  |                                                          | Academic year of realisation of subject |                                     | 2027/2028                                                                                                                                                                                                                                                                                                                     |            |     |
| Education level                             | Bachelor's studies                                                                                                                                                                                                                                                                            |                                                          | Subject group                           |                                     | Obligatory subject group in the field of study<br>Subject group related to scientific research in the field of study                                                                                                                                                                                                          |            |     |
| Mode of study                               | full-time studies                                                                                                                                                                                                                                                                             |                                                          | Mode of delivery                        |                                     | at the university                                                                                                                                                                                                                                                                                                             |            |     |
| Year of study                               | 3                                                                                                                                                                                                                                                                                             |                                                          | Language of instruction                 |                                     | Polish<br>Classes may be conducted in English in the following cases: - when the course is taught by an English-speaking instructor, - when a non-Polish-speaking international student is present in the group, - when the course is delivered by an invited external expert, - at the request of the students in the group. |            |     |
| Semester of study                           | 5                                                                                                                                                                                                                                                                                             |                                                          | ECTS credits                            |                                     | 3.0                                                                                                                                                                                                                                                                                                                           |            |     |
| Learning profile                            | academic                                                                                                                                                                                                                                                                                      |                                                          | Assessment form                         |                                     | credit                                                                                                                                                                                                                                                                                                                        |            |     |
| Conducting unit                             | Division of Atomic and Molecular Spectroscopy and Astrophysics -> Institute of Theoretical Physics and Astrophysics -> Faculty of Mathematics, Physics and Informatics -> Rector                                                                                                              |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
| Name and surname of lecturer (lecturers)    | Subject supervisor                                                                                                                                                                                                                                                                            |                                                          | dr hab. Piotr Gnaciński                 |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
|                                             | Teachers                                                                                                                                                                                                                                                                                      |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
| Lesson types                                | Lesson type                                                                                                                                                                                                                                                                                   | Lecture                                                  | Tutorial                                | Laboratory                          | Project                                                                                                                                                                                                                                                                                                                       | Seminar    | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                         | 30.0                                                     | 15.0                                    | 0.0                                 | 0.0                                                                                                                                                                                                                                                                                                                           | 0.0        | 45  |
|                                             | E-learning hours included: 0.0                                                                                                                                                                                                                                                                |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |
| Learning activity and number of study hours | Learning activity                                                                                                                                                                                                                                                                             | Participation in didactic classes included in study plan |                                         | Participation in consultation hours |                                                                                                                                                                                                                                                                                                                               | Self-study | SUM |
|                                             | Number of study hours                                                                                                                                                                                                                                                                         | 45                                                       |                                         | 0.0                                 |                                                                                                                                                                                                                                                                                                                               | 45.0       | 90  |
| Subject objectives                          | 1. To explain the structure of celestial bodies.<br>2. Understanding the interrelationships and interactions between astrophysical objects.<br>3. Explain the physical laws responsible for astrophysical phenomena.<br>4. To become familiar with the research methods used in astrophysics. |                                                          |                                         |                                     |                                                                                                                                                                                                                                                                                                                               |            |     |

| Learning outcomes | Course outcome                                                                                                                                                                                                                                                                                                          | Subject outcome                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Method of verification                                                   |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
|                   | [FIZL3_W10] has advanced knowledge of the elementary components of matter and the types of fundamental interactions between them, of the manifestations of these interactions in phenomena occurring on various scales from subatomic to astronomical, knows the time and energy scales associated with these phenomena | The student knows the methods of observing electromagnetic waves from gamma rays to radio waves, observing gravitational waves, neutrinos and cosmic rays.                                                                                                                                                                                                                                                                                                                                              | [SW4] test/exam - oral or written<br>[SW3] text preparation/written work |
|                   | [FIZL3_U09] can extrapolate the results obtained in the terrestrial laboratory to describe phenomena in the Universe                                                                                                                                                                                                    | The student is able to extrapolate the results obtained in the Earth laboratory to the Universe                                                                                                                                                                                                                                                                                                                                                                                                         | [SU3] text preparation/written work<br>[SU4] test/exam - oral or written |
|                   | [FIZL3_W05] understands astrophysical phenomena and the laws governing them, knows advanced physical processes taking place in the Universe                                                                                                                                                                             | The student knows:<br>1. The laws of physics that determine the course of astrophysical phenomena.<br>2. Astrophysical objects occurring in the Universe and relations between them.<br>3. Research methods used in astrophysics.<br>4. The role of astrophysics in the study of the laws of nature.<br>5. The structure of the Earth, Solar System bodies, Stars, Galaxies and the Universe.<br>6. The impact of astronomy and astrophysics on the development of physics, mathematics and technology. | [SW4] test/exam - oral or written<br>[SW3] text preparation/written work |
|                   | [FIZL3_W01] has advanced knowledge of physical concepts, principles and theories, understands their historical development and significance not only for physics, but also for other exact and natural sciences and cognition of the world                                                                              | The student knows:<br>1. The laws of physics that determine the course of astrophysical phenomena.<br>2. Astrophysical objects occurring in the Universe and relations between them.<br>3. Research methods used in astrophysics.<br>4. The role of astrophysics in the study of the laws of nature.<br>5. The structure of the Earth, Solar System bodies, Stars, Galaxies and the Universe.<br>6. The impact of astronomy and astrophysics on the development of physics, mathematics and technology. | [SW4] test/exam - oral or written<br>[SW3] text preparation/written work |

|                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                 |                               |
|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Subject contents                                               | 1. Elements of spherical trigonometry: spherical triangle, horizontal, equatorial and ecliptic coordinate system.<br>2. Astronomical time: true solar, mean solar and stellar time; calendar.<br>3. Astronomical observations: optical, radio, gamma-ray and satellite observations. Influence of the Earth's atmosphere on observations.<br>4 The structure of the Earth and the Earth's atmosphere; the ozone hole, the ionosphere, auroras, the greenhouse effect.<br>5. Kepler's lows in the context of the Planetary System. Space velocities.<br>6 Rotational, circular and precessional motion of the Earth.<br>7. The Earth-Moon system: orbit of the Moon, stellar, synodic and dragon months, solar and lunar eclipses, tides.<br>8. Review of physical properties of planets, moons and minor bodies of the Planetary System; gravitational resonance; other planetary systems.<br>9. Basic physical parameters of the Sun: mass, radius, effective temperature, chemical composition. Solar activity. The problem of solar neutrinos.<br>10. The Internal structure of the Sun - basic equations; thermonuclear reaction cycles; energy transport mechanisms.<br>11. Luminosities, temperatures, radii and masses of stars. H-R diagram.<br>12. Double stars and variable stars. Clusters and stellar associations.<br>13 Interstellar matter: dust and gas components, emission, reflection and dark nebulae.<br>14. Stellar evolution and its course in the H-R diagram. Late stages in the evolution of massive stars: supernovae, neutron stars, black holes.<br>15. Structure of the Galaxy: spiral structure, rotation, populations and subsystems. Distribution of interstellar matter in the Galaxy.<br>16. Other galaxies: classification and physical characteristics, determination of distances, active galaxy nuclei and quasars, galaxy clusters.<br>17. Elements of cosmology: Hubble's law, basic cosmological models, relic radiation (fluctuations), primordial nucleosynthesis, evolutionary history of the Universe (eras). |                                                                                                                                                                                                                                                                                                 |                               |
| Prerequisites and co-requisites                                | <ul style="list-style-type: none"><li>A. Passed subjects: major subjects from the first and second year of study and mathematical analysis and linear algebra.</li><li>B. Basic knowledge of atomic structure and elementary particles.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                 |                               |
| Assessment methods and criteria                                | Subject passing criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Passing threshold                                                                                                                                                                                                                                                                               | Percentage of the final grade |
|                                                                | exam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 51.0%                                                                                                                                                                                                                                                                                           | 50.0%                         |
|                                                                | final test                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 51.0%                                                                                                                                                                                                                                                                                           | 50.0%                         |
| Recommended reading                                            | Basic literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | H. Kartunen, P. Kroger, H. Oja, M. Poutanen,K.J. Donner, "Astronomia ogólna"<br>J. Kreiner, "Astronomia z Astrofizyką"                                                                                                                                                                          |                               |
|                                                                | Supplementary literature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | E. Rybka, Astronomia ogólna<br>J. Stodólkiewicz, Astrofizyka ogólna z elementami geofizyki<br>M. Kubiak, Gwiazdy i materia międzygwiazdowa<br>M. Jaroszyński, Galaktyki i budowa Wszechświata<br>A. Opolski, H. Cugier, T. Ciurla, Wstęp do astrofizyki<br>J. Mietelski, Astronomia w geografii |                               |
|                                                                | eResources addresses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                 |                               |
| Example issues/<br>example questions/<br>tasks being completed | not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                 |                               |
| Work placement                                                 | Not applicable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                 |                               |

Document generated electronically. Does not require a seal or signature.