BACHELOR 'S PROGRAMME
1st YEAR OF STUDY, 2nd SEMESTER

COURSE TITLE		INSTRUMENTATION IN ASTROPHYSICS
COURSE CODE		
COURSE TYPE		full attendance
COURSE LEVEL		1st cycle (bachelor's degree)
YEAR OF STUDY, SEMESTER		1st year of study, 2nd semester
NUMBER OF ECTS CREDITS		4
NUMBER OF HOURS PER WEEK		4 (2 lecture hours + 2 seminar hours)
NAME OF LECTURE HOLDER		Lect. dr. Valentin POHOAŢĂ
NAME OF SEMINAR HOLDER		Lect. dr. Valentin POHOAŢĂ
PREREQUISITES		Advanced level of English
A	GENERAL AND COURSE-SPECIFIC COMPETENCES	
	General competences: → Achievement of professional tasks efficiently and responsibly, in compliance with the field-specific deontology legislation, with qualified assistance. → Application of efficient work techniques in a multi-disciplinary team, on various hierarchical levels. → Effective use of information sources and communication resources and assisted professional training, both in Romanian and in a foreign language. **Course-specific competences:** → Derivation of working formulas for calculations with physical quantities using appropriate principles and laws of Physics. → Description of physical systems, using specific theories and tools (experimental and theoretical models, algorithms, schemes, etc.) → Application of the principles and laws of Physics in solving theoretical or practical problems, under qualified assistance conditions. → Correct application of methods of analysis and of criteria for choosing the appropriate solutions to achieve the specified performances. → Comparative assessment of the theoretical results offered by literature and of an experiment conducted in the framework of a professional project. → Elaboration of graphs and reports for explaining and interpreting physical results obtained by statistical methods. → Correlation of statistical analysis methods on a given topic (realization of measurements/calculations, data processing, interpretation). → Application of Physics knowledge both in given situations in related fields and in experiments, using standard laboratory equipment. → Explanation and interpretation of physical phenomena by formulating assumptions and operationalizing key concepts and proper use of laboratory equipment. → Identification of Physics and Informatics methods, techniques and tools; Design of Physics experiments using specific laboratory methods and equipment. → Critical assessment of the results obtained by employing a physical model, including the degree of uncertainty of the obtained experimental results. → Implementation, improvement and extension of physical model utilization. Making experimental devices capable of validating a physical model.	
B	LEARNING OUTCOMES	
	On successful completion of this subject, students will be able to: • On successful completion of this subject, students will be able to understand what spectral techniques are indicated for both qualitative and quantitative measurements.	
C	LECTURE CONTENT	
	Observing through the atmosphere. Atmospheric extinction, emission, refraction. Cosmic microwave background. The Hubble constant. Celestial backgrounds. Elastic light scattering on interstellar dust medium (ISM) – Rayleigh scattering, Mie scattering, Non-selective scattering or geometrical scattering. Atomic Spectroscopy – X-ray, Visible and Ultraviolet Spectral range Molecular Spectroscopy - Ultraviolet and Visible Spectral range Fluorescence spectroscopy: Atomic X-ray fluorescence (XRF) and UV molecular fluorescence Vibrational Spectroscopy. Infrared spectroscopy. Broadening mechanisms on spectral lines, shifts and splits. (Doppler, Stark and Zeeman effects) Shifts on spectral lines. (Doppler effect)	

Optical components used in various types of spectrometers (filters, diaphragms, gratings, mirrors)
Main types of instrument: cameras, photometers, CCD detectors, solid state detectors.
Main types of instrument: Fabry-Perot spectrometer, Fourier transform spectrometer (Michelson interferometer).
Detection of gravitational waves - LIGO
Atmospheric Cerenkov Telescope Array (neutrino detection)

D RECOMMENDED READING FOR LECTURES

1. Bely, P.-Y., ed., 2003. The design and construction of large optical telescopes, Astronomy and astrophysics library (New York: Springer, 2003).
2. Dalgarno, A. and D. Layzer, eds., 1987. Spectroscopy of astrophysical plasmas, Cambridge astrophysics series, 7 (Cambridge, CB ; New York: Cambridge University Press, 1987).
3. Kitchin, C. R. 1995. Optical astronomical spectroscopy (Bristol ; Philadelphia: Institute of Physics Pub, 1995).
4. Electronic imaging in astronomy. McLean, I. S. 2008. Electronic imaging in astronomy: detectors and instrumentation, (2nd ed) (Berlin ; New York : Chichester, UK: Springer ; Published in association with Praxis Pub, 2008).
5. Pradhan, A. K. and S. N. Nahar 2011. Atomic Astrophysics and Spectroscopy (Cambridge: Cambridge University Press, 2011) (DOI: 10.1017/CBO9780511975349).
6. Schroeder, D. J. 2000. Astronomical optics, (2nd ed) (San Diego: Academic Press, 2000).
7. Stellar pulsations. Suárez, J. C., ed., 2012. Stellar pulsations: impact of new instrumentation and new insights, Astrophysics and space science proceedings, 31 (Berlin ; New York: Springer, 2012).
8. Observational Astronomy. Sutton, E. C. 2011. Observational Astronomy: Techniques and Instrumentation (Cambridge: Cambridge University Press, 2011) (DOI: 10.1017/CBO9780511862335).
9. Spectroscopic instrumentation. Thomas Eversberg and Klaus Vollmann 2014. Spectroscopic instrumentation: fundamentals and guidelines for astronomers (New York: Springer, 2014).
10. LIGO Lab | Caltech | MIT LIGO Lab | Caltech <https://www.ligo.caltech.edu/>, accessed 4 February 2019.

E SEMINAR / LABORATORY CONTENT

How Edwin Hubble determine that the Universe is expanding?
The Solar UV-Visible spectrum. The Earth atmosphere influence.
Spectra of the gaseous nebulae and their compositional interpretation.
The Sun magnetic field strength calculated from the Natrium doublet Zeeman spitting lines.
Spectroscopy of Planetary Nebulae
Quasar’s spectra.
Binary star system observed by Doppler shift of Hydrogen alpha line.
FTIR spectrometer: technical specifications. Michelson interferometer.
Infrared spectra of Planets. The planets temperature from black-body radiation spectra.
Infrared spectra of Interstellar dust medium. (Silicates and Carbonaceous dust)
IR Spectra analysis, deconvolution of fine structure peaks.
X ray bursts spectra (solid state detectors - energy dispersive x-ray spectroscopy)
Gamma-ray bursts and gravitational wave strain signal from Kilonovas
Laboratory colloquium

F RECOMMENDED READING FOR SEMINARS

1. Laboratory reports (.pdf)
2. Laboratory experiments in physics for modern astronomy. Golden, L. M. 2013. Laboratory experiments in physics for modern astronomy: with comprehensive development of the physical principles (New York ; London: Springer, 2013).
3. Kitchin, C. R. 1995. Optical astronomical spectroscopy (Bristol ; Philadelphia: Institute of Physics Pub, 1995).
4. Electronic imaging in astronomy. McLean, I. S. 2008. Electronic imaging in astronomy: detectors and instrumentation, (2nd ed) (Berlin ; New York : Chichester, UK: Springer ; Published in association with Praxis Pub, 2008).
5. Schlosser, W., T. Schmidt-Kaler, and E. F. Milone 2013. Challenges of astronomy: hands-on experiments for the sky and laboratory (Springer Science & Business Media, 2013).
6. Schroeder, D. J. 2000. Astronomical optics, (2nd ed) (San Diego: Academic Press, 2000).
7. Observational Astronomy. Sutton, E. C. 2011. Observational Astronomy: Techniques and Instrumentation (Cambridge: Cambridge University Press, 2011) (DOI: 10.1017/CBO9780511862335).
8. Spectroscopic instrumentation. Thomas Eversberg and Klaus Vollmann 2014. Spectroscopic instrumentation: fundamentals and guidelines for astronomers (New York: Springer, 2014).
9. Walker, P. and E. Wood 2010. Space and astronomy experiments, Facts on File science experiments (New York, NY: Facts on File, 2010).
10. Hodoroaba, B., I. C. Gerber, D. Ciubotaru, I. Mihaila, M. Dobromir, V. Pohoata, and I. Topala 2018. “Carbon ‘fluffy’ aggregates produced by helium–hydrocarbon high-pressure plasmas as analogues to interstellar dust,” Monthly Notices of the Royal Astronomical Society, 481/2 (2018), 2841–2850

	11. LIGO Lab | Caltech | MIT LIGO Lab | Caltech <https://www.ligo.caltech.edu/>, accessed 4 February 2019.
G	EDUCATION STYLE

LEARNING AND TEACHING METHODS	Essays, laboratory work
ASSESSMENT METHODS	• summative evaluation • formative evaluation
LANGUAGE OF INSTRUCTION	English