Introduction to Astrophysics
- COURSE SYLLABUS

1.	**Course title:**	
	Introduction to Astrophysics	
2.	**Lecturers:**	
	dr hab. Krzysztof Nalewajko, prof. dr hab. Krzysztof Belczyński, prof. dr hab. Ewa Łokas, dr Stanisław Bajtlik	
3.	**Field, type and level of studies, year of study:**	
	astrophysics, obligatory for I-III year students at CAMK, elective monograph lecture for GeoPlanet doctoral school	
4.	**Course character:**	
	monographic lecture	
5.	**Teaching method:**	
	traditional and/or on-line	
6.	**Language:**	*English*
7.	**Course type and number of hours:**	
	lectures, 32h	
8.	**Estimated load of student's independent work:**	*30h*
9.	**Total workload and number of ECTS points:**	*60 h, 3 ECTS*
10.	**Short description and main focus of the course:**	
	The course is intended to provide a broad introduction to astrophysics at an introductory level. It will be composed of four parts. **PART I: Radiative Processes (dr hab. K. Nalewajko)** 1) radiation measures (intensity, flux, luminosity, energy density, pressure), polarization (linear, circular) 2) thermal radiation, radiation transport (emission, absorption, optical depth), radiation diffusion (Eddington, Rosseland) 3) relativity (invariants, Doppler effect, aberration, luminosity boost), radiation from moving charges, bremsstrahlung (emission, free-free absorption) 4) synchrotron radiation (spectrum, synchrotron self-absorption), curvature 5) inverse-Compton radiation (Thomson, Klein-Nishina, synchrotron self-Compton, Y parameter)	

6) pair production and annihilation, hadronic processes (proton synchrotron, photo-mesonic cascades), Faraday rotation
7) spectral lines (atoms, transitions, ionization)
8) cosmic radiation background, atmospheric windows, multiwavelength observations

PART II: Stars (prof. dr hab. K. Belczyński)

1) hydrostatic equilibrium, virial theorem, the Jeans criterion
2) radiation transport; intensity, flux, luminosity
3) radiation transport: opacity, equation of radiation transport, optical depth
4) the equations of stellar structure, equation of state
5) convection: radiative and adiabatic temperature gradients, mixing-length theory
6) the Schwarzschild criterion, effects of rotation, overshooting and mass loss
7) nuclear reactions: H->He, main sequence lifetime, solar neutrinos
8) nuclear reactions: He->Fe, the Hoyle objection, neutronization of matter
9) formation of compact objects: white dwarfs, neutron stars and black holes

PART III: Galaxies (prof. dr hab. E. Łokas)

1) Structure of galaxies: haloes and disks, circular velocities, NFW profile, exponential disk, Sersic profile
2) The Milky Way and galaxies of the Local Group
3) Orbits of stars in different potentials
4) Distribution functions, Jeans modeling, orbit-superposition models
5) Bars in galaxies: formation, evolution, orbital structure, dependence on environment
6) Spiral structure: geometry of spiral arms, formation scenarios
7) Interactions: tidal evolution and mergers, properties of merger remnants
8) Galaxy formation in cosmological context, cold and hot dark matter scenarios, top hat model, problems of theory on small scales

PART IV: Cosmology (dr S. Bajtlik)

1) Homogeneous Universe, arguments for and against;
2) Cosmological models, their theoretical and observational status;
3) primary nucleosynthesis and the cosmological significance of its results;
4) the origin and significance of background radiation;
5) the importance of discovering background radiation, looking for evidence of its thermal nature and the significance of it;
6) the origin of the cosmic structure, gravitational instability
7) dark matter and dark energy, the biggest unsolved problem in physics;
8) evidence of dark matter and dark energy;
9) cosmological unresolved problems and prospects for solving them.

11. References:

PART I:

- "Radiative processes in Astrophysics" - Rybicki & Lightman (A Wiley-Interscience publication)
- "High energy astrophysics - particles, photons, and their detection" -- Longair (Cambridge University Press)
- "Radiative processes in high energy astrophysics" - Ghisellini (arXiv:1202.5949)

PART II:

- An Introduction to Stellar Astrophysics by LeBlanc (basic level)
- Stellar Structure and Evolution by Kippenhahnm, Weigert, Weiss - free access

	through CAMK intranet: https://link.springer.com/book/10.1007/978-3-642-30304-3 ● Stellar Structure and Evolution by Prialnik (advanced level) *PART III:* ● J. Binney, S. Tremaine, „Galactic dynamics”, 2008 ● L. Sparke, J. Gallagher, „Galaxies in the universe”, 2007 ● P. Schneider, „Extragalactic astronomy and cosmology”, 2006 ● H. Mo, F. van den Bosch, S. White, „Galaxy formation and evolution”, 2010 ● M.S. Longair, „Galaxy formation”, 1998 *PART IV:* ● P.J.E. Peebles, "Principles of Physical Cosmology", Princeton University Press, 1993 ● P.J.E. Peebles, "Cosmology's century. An insight history of our modern understanding of the Universe", Princeton University Press, 2020 ● J.P. Ostriker, Simon Mitton, "The heart of darkness. Unraveling the Mysteries of the Invisible Universe", Princeton University Press, 2013	
12.	**Prerequisites:** *none*	
13.	**Educational outcomes:**	**PQF level 8 codes:**
	Knowledge: *Student knows and understands:* - *the world’s achievements relating to theoretical foundations, general and selected specific issues of astrophysics;* - *the main scientific developments in astrophysics;* - *the methodology of scientific research*	*P8S_WG*
	Practical Skills: *Student is able to:* - *take advantage of the knowledge gained on the lecture to creatively identify, formulate and innovatively solve complex problems or perform research activities, in particular to define the aim and subject of the research, formulate a research hypothesis develop research methods, techniques and tools and use them creatively, draw conclusions on the basis of research results* - *perform critical analysis and evaluation of the results of scientific research;* - *communicate on specialized topics to a degree that enables active participation in an international scientific environment;* - *use a foreign language at B2 level of the Common European Framework of Reference for Languages to the extent that enables participation in international academic and professional communities*	*P8S_UW, P8S_UK*
	Social Skills: *Student is ready to:* - *critically evaluate the achievements in the field of astrophysics;* - *critically evaluate one’s contributions to the development of that field;* - *recognize the value of knowledge in solving cognitive and practical problems*	*P8S_KK*

14.	**Evaluation of the educational outcomes:**
	written and oral (resit) exam
15.	**Criteria to complete the course:**
	a maximum of 2 unexplained absences, a positive final grade (3 or above)
16.	**Contact with the lecturer:**
	dr hab. Krzysztof Nalewajko, knalew@camk.edu.pl *prof. dr hab. Krzysztof Belczyński, belczynski@camk.edu.pl* *prof. dr hab. Ewa Łokas, lokas@camk.edu.pl* *dr Stanisław Bajtlik, bajtlik@camk.edu.pl*