

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-II-S-23/24Z-K						
Course title: Introduction to the standard model of elementary particles (wprowadzenie do modelu standardowego cząstek elementarnych)					Course code: SPR16AIJ3445_55S	
Name of field of study: fizyka						
Mode and cycle of study: second degree, full - time			Profile of study: general academic		Specialty: kosmologia	
Course / module status obligatory				Language of instruction: semester: 2 - polish language		
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS
				w tym e-learning		
1	2	konwersatorium	30	0	pg	5
Total			30			5
Course / module coordinator		dr hab. MARCIN PIĄTEK				
Course instructor		dr hab. MARCIN PIĄTEK				
Course / module objectives		To acquaint students with the currently prevailing theory of the microscopic structure of matter and fundamental interactions. Acquiring by students the ability to use mathematical tools to solve basic tasks and problems in the field of elementary particles.				
Prerequisites		theoretical mechanics, electrodynamics, quantum physics				
LEARNING OUTCOMES						
Category	No.	Code	Description	Ref. to programme benchmarks		
knowledge	1	EP1	Student knows the fundamental components of matter and fundamental interactions.	K_W01 K_W05 K_W06		
	2	EP2	Student understands the role of symmetry in the construction of the fundamental laws of physics and knows the basic scheme of the construction of the standard model.	K_W01 K_W05		
	3	EP3	Student understands the role of mathematics in learning and describing the laws of nature	K_W02 K_W06		
	4	EP4	Student is aware of the limitations of the standard model in the description of new physical phenomena.	K_W01 K_W02		
skills	1	EP5	Student knows how to apply the field theory tools in the description of elementary particle physics.	K_U01 K_U05 K_U06		
	2	EP6	Student uses arguments based on the conservation laws and symmetry for the analysis of physical processes.	K_U01 K_U05 K_U06		
social competences	1	EP7	Student understands the need to deepen physical knowledge.	K_K01		
	2	EP8	Student can search for information in the literature.	K_K06		
CONTENT					Semester	No. of hours
						w tym e-learning
Subject title: wprowadzenie do modelu standardowego cząstek elementarnych						

Format of instruction: konwersatorium					
1. What is the standard model of elementary particles?		2	2	0	
2. Spacetime geometry		2	2	0	
3. Klein-Gordon equation		2	2	0	
4. Dirac equation and Dirac bispinors		2	4	0	
5. Particles with spin 0		2	2	0	
6. Particles with spin 1/2		2	2	0	
7. Interacting fields		2	3	0	
8. Global gauge symmetries		2	2	0	
9. Local gauge symmetry		2	2	0	
10. Electroweak interactions		2	2	0	
11. Higgs mechanism		2	2	0	
12. Phenomenology of electroweak interactions		2	3	0	
13. Strong interactions		2	2	0	
Modes of delivery	solving problems and tasks based on the information and examples given during the lecture				
Assessment methods				No. of learning outcome from the syllabus	
	KOLOKWIUM			EP1,EP2,EP3,EP4,EP5,EP6,EP7,EP8	
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.				
Grading criteria	passing a test				
	Grade calculation principles				
	według standardowych kryteriów oceny osiągniętych efektów kształcenia				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	wprowadzenie do modelu standardowego cząstek elementarnych		Arytmetyczna	
	2	wprowadzenie do modelu standardowego cząstek elementarnych [konwersatorium]	zaliczenie z oceną		
Basic reading	D. H. Perkins (2004): Wstęp do fizyki wysokich energii, PWN, Warszawa				
Supplementary reading	Krzysztof A. Meissner (2022): Klasyczna teoria pola, PWN, Warszawa				
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	30		0		
Participation in test / exam	2		0		
Preparation for contact hours	21		0		
Private reading and studying	26		0		
Participation in tutorials	30		0		
Preparation of project / essay / etc.	0		0		

Preparation for test / exam	16	0
TOTAL workload	125	
ECTS credits	5	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-IS-21/22Z						
Unit: Astronomia [moduł]						
Course title: Astrobiology (astrobiologia)					Course code: SPR16AIJ3445_71S	
Name of field of study: fizyka						
Mode and cycle of study: first-degree, full - time			Profile of study: general academic		Specialty:	
Course / module status elective				Language of instruction: semester: 6 - polish language		
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS
				w tym e-learning		
3	6	konwersatorium	40	0	e	5
Total			40			5
Course / module coordinator		prof. dr hab. EWA SZUSZKIEWICZ				
Course instructor		prof. dr hab. EWA SZUSZKIEWICZ				
Course / module objectives		The aim of the course is to introduce the basic concepts of astrobiology. In the first part, the general picture of astrobiology is presented. The second part is dedicated to more advanced topics. During this course, students will have an opportunity to participate in the lectures given by the known astrobiologists from other universities and research institutions, taking place on the videoconference platforms. This will help in showing to students a wider and more complete perspective of the research in astrobiology.				
Prerequisites		Astronomy, fundamentals of Physics and Chemistry				
LEARNING OUTCOMES						
Category	No.	Code	Description	Ref. to programme benchmarks		
knowledge	1	EP1	Student is familiar with basic concepts, laws and theoretical formulations in the field of Astrobiology.	K_W01		
skills	1	EP2	Student is able to write an essay in English presenting the physical aspects of astrobiology	K_U18		
	2	EP3	Student is able to discuss the timely topics of the astronomical and astrobiological research	K_U17 K_U19		
	3	EP4	Student is able to formulate basic laws of Physics using the mathematical tools	K_U05		
	4	EP5	Student is able to evaluate physical quantities to the order of magnitude and is aware of the importance of making the approximations in the description of observed phenomena	K_U09		
social competences	1	EP6	Student is ready to make effort to understand better the subject of Astrobiology and to discuss the topics with others to solve a given problem	K_K02 K_K05		
	2	EP7	Student is ready to give her/his opinion on the basic problems and scientific theories connecting the different disciplines and being of interest to the wide audience	K_K05		
CONTENT					Semester	No. of hours
						w tym e-learning
Subject title: astrobiologia						
Format of instruction: konwersatorium						

1. Part I: Basic concepts of Astrobiology		6	20	0	
2. Part II: Advanced topics of Astrobiology		6	20	0	
Modes of delivery	Introduction of the new concepts illustrated by numerous examples. The team work and individual research during the exercise classes				
Assessment methods				No. of learning outcome from the syllabus	
	EGZAMIN PISEMNY			EP3,EP4,EP5	
	KOLOKWIUM			EP1,EP3,EP4,EP6,EP7	
	PRACA PISEMNA/ ESEJ/ RECENZJA			EP2,EP4	
Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.					
Grading criteria	Written exam, essay, one test The final mark is a weighted average on the exam, essay and test				
	Grade calculation principles				
	FS = 50% * SE1 + 10% SE2 + 40% * SE3 FS = final mark, SE1 = mark of the exam, SE2 = mark on the essay, SE3 = mark on the test				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	6	astrobiologia		Ważona	
	6	astrobiologia [konwersatorium]	egzamin		1,00
Basic reading	Franco Ferrari : Slajdy i notatki z wykładów umieszczone na stronie internetowej przedmiotu: http://www.astrobiologia.pl/~ferrari/didactics				
	Franco Ferrari i Ewa Szuszkiewicz (2006): Astrobiologia: Poprzez pył kosmiczny do DNA, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin				
	Jonathan Irving Lunine (2005): Astrobiology : a multidisciplinary approach, Pearson Addison Wesley, San Francisco				
Supplementary reading	Iain Gilmour oraz Mark A. Sephton (2005): An Introduction to Astrobiology, Cambridge University Press , Cambridge				
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	40		0		
Participation in test / exam	2		0		
Preparation for contact hours	8		0		
Private reading and studying	20		0		
Participation in tutorials	22		0		
Preparation of project / essay / etc.	23		0		
Preparation for test / exam	10		0		
TOTAL workload	125				
ECTS credits	5				

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-I-S-21/22Z							
Unit: Fizyka teoretyczna [moduł]							
Course title: Field Theory (teoria pola)					Course code: SPR16AIJ3445_62S		
Name of field of study: fizyka							
Mode and cycle of study: first-degree, full - time			Profile of study: general academic		Specjalty:		
Course / module status elective				Language of instruction: semester: 5 - polish language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
3	5	konwersatorium	30	0	pg	4	
		lecture	10	0	pg		
Total			40			4	
Course / module coordinator		dr hab. FRANCO FERRARI					
Course instructor		dr hab. FRANCO FERRARI					
Course / module objectives		The main concepts of field theory will be introduced by following the historical development of the subject passing from quantum mechanics to relativistic quantum mechanics and arriving to the modern field theoretical formulation. This course is dedicated to those, who want to deepen their knowledge on quantum mechanics and relativity.					
Prerequisites		Required is the knowledge acquired during the following courses: quantum mechanics, theoretical mechanics, statistical physics, condensed matter physics and mathematical methods of physics.					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	Student posiada wiedzę szczegółową z fizyki w zakresie teorii pola oraz ich zastosowań. Rozumie znaczenie podstawowych koncepcji, zasad i teorii, a także ich historyczny rozwój i znaczenie dla postępu nauk ścisłych poznania świata i rozwoju ludzkości	K_W01 K_W20			
skills	1	EP2	Student potrafi posługiwać się aparatem matematycznym w zakresie niezbędnym dla ilościowego opisu i modelowania problemów fizyki wysokich energii i fizyki statystycznej	K_U05			
	2	EP4	Student potrafi zapoznać się z fachową literaturą naukową w ramach swojej specjalności.	K_U20			
	3	EP6	student potrafi przygotować ustne wystąpienie dotyczące wybranego tematu z teorii pola	K_U19			
social competences	1	EP5	Student jest gotów konsultować się z innymi w celu rozwiązania zadanego problemu i pogłębiać własne zrozumienie danego tematu.	K_K02			
CONTENT					Semester	No. of hours	
						w tym e-learning	
Subject title: teoria pola							
Format of instruction: lecture							
1. Wstęp do teorii pola					5	1	0
2. Zaawansowana teoria względności					5	2	0

3. Przypadek pola skalarnego		5	2	0	
4. Równanie Diraca		5	2	0	
5. Drugie kwantowanie		5	3	0	
Format of instruction: konwersatorium					
1. konwersatorium i ćwiczenia dotyczące zagadnień z teorii pola		5	20	0	
2. dyskusje na temat teorii pola		5	7	0	
3. Przygotowanie i przedstawienie prezentacji studentów		5	3	0	
Modes of delivery	Lectures will be followed by examples. During test classes, problems will be solved in group or individually. The preparation of an essay on a subject of field theory is required as an homework.				
Assessment methods				No. of learning outcome from the syllabus	
	KOŁOKWIUM			EP1,EP2	
	PREZENTACJA			EP4,EP5,EP6	
	ZAJĘCIA PRAKTYCZNE (WERYFIKACJA POPRZECZ OBSERWACJĘ)			EP5	
Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.					
Grading criteria	Wykład: uzyskanie pozytywnej oceny po przygotowaniu prezentacji oraz jej przedstawieniu Konwersatorium: kolokwium				
	Grade calculation principles				
	$FS = 50\% * SE1 + 50\% * SE2$ FS= ocena końcowa, SE1 = ocena z prezentacji, SE2 = ocena z kolokwium,				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	5	teoria pola		Ważona	
	5	teoria pola [wykład]	zaliczenie z ocena		0,50
	5	teoria pola [konwersatorium]	zaliczenie z ocena		0,50
Basic reading	Albert Messiah (1978): Quantum Mechanics, North-Holland, Amsterdam				
	Zinn-Justin J. (1996): Quantum field theory and critical phenomena, Oxford University Press, Oxford				
Supplementary reading	Bogoliubow I., Szirkow D. (1976): Wwiedzenie w teorii kwantowanych pole, Nauka Moskva				
	Peskin, Michael E., Daniel V. Schroeder (1996): An Introduction to Quantum Field Theory, Westview Press, Boulder, CO				
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	40		0		
Participation in test / exam	2		0		
Preparation for contact hours	16		0		
Private reading and studying	10		0		
Participation in tutorials	8		0		
Preparation of project / essay / etc.	12		0		
Preparation for test / exam	12		0		
TOTAL workload	100				
ECTS credits	4				

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-I-S-22/23Z						
Course title: Astronomy (astronomia)					Course code: SPR16AIJ3445_11S	
Name of field of study: fizyka						
Mode and cycle of study: first-degree, full - time			Profile of study: general academic		Specialty:	
Course / module status obligatory			Language of instruction: semester: 2 - english language polish language, semester: 3 - english language polish language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS
				w tym e-learning		
1	2	lecture	15	0	pg	2
2	3	konwersatorium	30	0	e	3
Total			45			5
Course / module coordinator		prof. dr hab. EWA SZUSZKIEWICZ				
Course instructor		prof. dr hab. EWA SZUSZKIEWICZ				
Course / module objectives		A good understanding of the nature of astronomical phenomena and the underlying fundamental laws, correct use of astronomical terminology, acquire the ability to assess the current state of the astronomical research, develop the capacity of performing simple astronomical observations				
Prerequisites		Familiarity with the differential calculus: derivatives and integrals of one and more variables, basic knowledge of Algebra, necessary to describe the physical phenomena and solve physical problems; familiarity with the laws of motion of the pointlike masses and rigid bodies, as well as relativistic mechanics; knowledge of basic laws in electricity and magnetism; ability to formulate basic physical laws using mathematical apparatus; awareness of the limitations of the own knowledge and understanding of the need to learn more.				
LEARNING OUTCOMES						
Category	No.	Code	Description	Ref. to programme benchmarks		
knowledge	1	EP1	A student understands the nature of astronomical phenomena and the underlying fundamental laws	K_W01 K_W07		
skills		EP2	A student is able to use correctly the astronomical terminology,	K_U12 K_U16 K_U17 K_U18 K_U19 K_U22		
	2	EP3	A student possesses the ability to assess the current state of the astronomical research	K_U12 K_U16 K_U20 K_U22		
	3	EP4	A student is able to perform simple astronomical observations	K_U02 K_U04 K_U09 K_U13 K_U16		
	4	EP5	A student is able to discuss a particular problem with a group of her/his colleagues and remain open on their argumentations	K_U17 K_U21		
social competences	1	EP6	A student understands a need to disseminate the knowledge of astronomy to a wide public, is ready to take part in the organisation of the public lectures, the night sky shows or other outreach events dedicated to astronomy	K_K04 K_K05		

CONTENT		Semester	No. of hours	
				w tym e-learning
Subject title: astronomia				
Format of instruction: lecture				
1. Content of the Univers		2	1	0
2. Astronomical instrumentation		2	1	0
3. The Sun		2	1	0
4. Last stages of the stellar evolution		2	1	0
5. Evolution of low-mass stars		2	1	0
6. Evolution of massive stars		2	1	0
7. Binary stars		2	1	0
8. Accretion discs		2	1	0
9. Stellar systems		2	1	0
10. Interstellar medium		2	1	0
11. Galaktyki spokojne i aktywne		2	1	0
12. Systems of galaxies		2	1	0
13. Materia międzygalaktyczna i wielkoskalowa struktura Wszechświata		2	1	0
14. Planety i życie		2	1	0
15. Esej astronomiczny		2	1	0
Format of instruction: konwersatorium				
1. Getting familiar with the night sky		3	3	0
2. Measuring sizes and distances in Astronomy		3	3	0
3. Observation of the Sun		3	3	0
4. Stellar prperties		3	3	0
5. Stella evolution		3	3	0
6. Accretion processes		3	3	0
7. Observations of stars		3	4	0
8. Planets		3	4	0
9. Observations of planets		3	4	0
Modes of delivery	Lecture with the multimedial presentations, astronomical observations using simple amateur telescopes, obseravions of the Sun, observations of the interesting objects at the evening sky, use of maps, atlases and catalogues			
Assessment methods			No. of learning outcome from the syllabus	
	EGZAMIN PISEMNY		EP1,EP2,EP3,EP4,E P5,EP6	
	PROJEKT		EP1,EP2,EP4,EP6	
	ZAJĘCIA PRAKTYCZNE (WERYFIKACJA POPRZEZ OBSERWACJĘ)		EP5	
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.			

Grading criteria	discussion session: passing the written exam lecture: obtaining a credit from the oral test, being active during the classes				
	Grade calculation principles				
	The mark from the exam makes the final grade. There is a possibility to increase the final grade if the student is active during the classes				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	astronomia		Ważona	
	2	astronomia [wykład]	zaliczenie z oceną		1,00
	3	astronomia		Ważona	
	3	astronomia [konwersatorium]	egzamin		1,00
Basic reading	Shu Frank H. (2003): Galaktyki Gwiazdy Życie, Fizyka Wszechświata, Prószyński i S-ka, Warszawa				
	teksty źródłowe podawane na wykładzie :				
Supplementary reading	Artymowicz P. (1995): Astrofizyka układów planetarnych, PWN, Warszawa				
	Jaroszyski M. (1993): Galaktyki i Budowa Wszechświata, PWN, Warszawa				
	Kreiner J. M. (1992): Astronomia z astrofizyką, PWN, Warszawa				
	Kubiak M. (1994): Gwiazdy i materia międzygwiazdowa, PWN, Warszawa				
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	45		0		
Participation in test / exam	5		0		
Preparation for contact hours	15		0		
Private reading and studying	20		0		
Participation in tutorials	15		0		
Preparation of project / essay / etc.	10		0		
Preparation for test / exam	15		0		
TOTAL workload	125				
ECTS credits	5				

COURSES YLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-II-S-23/24Z-K							
Course title: Mathematical methods of physics II (matematyczne metody fizyki II)					Course code: SPR16AIIJ3445_49S		
Name of field of study: fizyka							
Mode and cycle of study: second degree, full - time			Profile of study: general academic		Specialty: kosmologia		
Course / module status obligatory				Language of instruction: semester: 2 - polish language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
1	2	konwersatorium	30	0	e	2	
Total			30			2	
Course / module coordinator		dr hab. MARCIN PIĄTEK					
Course instructor		dr hab. MARCIN PIĄTEK					
Course / module objectives		Mastering by the student basic tools of complex analysis, differential geometry, theory of distribution and integral operators, theory of ordinary and partial differential equations.					
Prerequisites		basic knowledge of algebra and mathematical analysis in terms of undergraduate physics studies					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	Student learns advanced methods of higher mathematics necessary for an in-depth study of physics and related disciplines.	K_W01 K_W02			
	2	EP2	Student learns concepts and techniques necessary to solve ordinary and partial differential equations.	K_W02 K_W05 K_W06			
skills	1	EP3	Student knows how to apply methods of higher mathematics to problems of natural sciences.	K_U01 K_U04			
	2	EP4	Student has accounting skills in solving simple ordinary and partial differential equations.	K_U05 K_U06			
social competences	1	EP5	Student understands the need to constantly expand their knowledge and acquire new technical skills.	K_K01 K_K02			
CONTENT					Semester	No. of hours	
							w tym e-learning
Subject title: matematyczne metody fizyki II							
Format of instruction: konwersatorium							
1. Holomorphic functions					2	5	0
2. Elements of differential geometry					2	5	0
3. Second-order ordinary differential equations with varying coefficients					2	6	0
4. Distributions and integral operators					2	4	0
5. First order partial differential equations. The wave equation					2	4	0
6. Initial and boundary problems for different types of second-order partial differential equations					2	6	0
Modes of delivery		Standard form of the lecture. Students are stimulated to ask questions and discuss. In order to consolidate the processed material, they receive sets of homework and problems to solve on their own.					

Assessment methods					No. of learning outcome from the syllabus
	EGZAMIN PISEMNY				EP1,EP2,EP3,EP4,EP5
Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.					
Grading criteria	passed test				
	Grade calculation principles				
	arithmetic average				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	matematyczne metody fizyki II		Ważona	
	2	matematyczne metody fizyki II [konwersatorium]	egzamin		1,00
Basic reading	W. Żakowski, W. Leksiński (1984): Matematyka, część IV, WNT, Warszawa				
	A. Zagórski (2007): Metody matematyczne fizyki, Oficyna Wyd. PW, Warszawa				
	F. Byron, R. Fuller (1975): Matematyka w fizyce klasycznej i kwantowej, PWN, Warszawa				
Supplementary reading	B. Szabat (1974): Wstęp do analizy zespolonej, PWN, Warszawa				
	L. Evans (2002): Równania różniczkowe cząstkowe, PWN, Warszawa				
	W. Smirnow (1966): Matematyka wyższa, tom II,, PWN, Warszawa				
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	30		0		
Participation in test / exam	3		0		
Preparation for contact hours	8		0		
Private reading and studying	5		0		
Participation in tutorials	4		0		
Preparation of project / essay / etc.	0		0		
Preparation for test / exam	0		0		
TOTAL workload	50				
ECTS credits	2				

COURSESYLLABUSANDSPECIFICATION

Curriculum title: USSPR-F-O-I-S-21/22Z							
Unit: Kosmologia [moduł]							
Course title: Modern observational probes of cosmology (współczesne testy obserwacyjne kosmologii)					Course code: SPR16AIJ3445_92S		
Name of field of study: fizyka							
Mode and cycle of study: first-degree, full - time			Profile of study: general academic		Specjalty:		
Course / module status elective				Language of instruction: semester: 6 - polish language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
3	6	konwersatorium	40	0	pg	5	
Total			40			5	
Course / module coordinator		dr hab. VINCENZO SALZANO					
Course instructor		dr hab. VINCENZO SALZANO					
Course / module objectives		The aim of the course is to familiarize students with the main observational tests that are currently used in cosmology. Students can have a general knowledge about the status of observational cosmology, be able to discuss about them, and can decide if to continue these studies in the master programme.					
Prerequisites		Completed courses in "Astronomy" and "General Theory of Relativity" (optional), "Elements of Cosmology" (optional), "Theory of Gravity" (optional)					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	knows the phenomena and the basic quantities which can be measured in cosmology and can be used to understand the evolution of the Universe	K_W05 K_W06 K_W07			
skills	1	EP2	understands the connection between local astronomical and astrophysical quantities with the evolution of the Universe on cosmological scales	K_U03 K_U15 K_U16			
	2	EP3	discusses and works in a team and is open on the arguments of others	K_U17 K_U21			
social competences		EP4	The student knows the limits of his own knowledge and understands the need for further education	K_K01 K_K02			
	2	EP5	The student can formulate precise questions to deepen his/her own understanding of a topic or to find missing pieces of reasoning	K_K05			
CONTENT					Semester		
					No. of hours		
					w tym e-learning		
Subject title: współczesne testy obserwacyjne kosmologii							
Format of instruction: konwersatorium							
1. Introduction to observational cosmology					6	3	0
2. Cosmological distances					6	2	0
3. Sandage-Loeb test (redshift drift)					6	1	0
4. Cosmic Chronometers					6	2	0

5. Cosmological ladder: parallax; surface brightness method; Tully-Fisher relation; fundamental plane of elliptical galaxies	6	2	0
6. Cosmological ladder: Cepheids	6	2	0
7. Cosmological ladder: megamasers	6	1	0
8. Cosmological ladder: Type Ia Supernovae (SNeIa)	6	3	0
9. Local measurement of the Hubble constant	6	2	0
10. Cosmological ladder: gamma ray bursts	6	2	0
11. Cosmological ladder: quasars	6	2	0
12. Cosmic Microwave Background (CMB)	6	5	0
13. Baryon Acoustic Oscillation (BAO)	6	4	0
14. Gravitational lensing; strong lensing; weak lensing; cosmological weak lensing	6	5	0
15. Black hole and gravitational waves	6	4	0

Modes of delivery	Lectures made using computer presentation and discussion of scientific papers				
Assessment methods					No. of learning outcome from the syllabus
	PROJEKT				EP1,EP2,EP3,EP4,EP5
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.				
Grading criteria	Seminar: passing the project				
	Grade calculation principles				
	Evaluation of the project presentation				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	6	współczesne testy obserwacyjne kosmologii		Ważona	
	6	współczesne testy obserwacyjne kosmologii [konwersatorium]	zaliczenie z oceną		1,00
Basic reading	A. Liddle (2015): An Introduction to Modern Cosmology				
	O. F. Piattella (2018): Lecture Notes in Cosmology				
	S. Serjeant (2010): Observational Cosmology				
	źródła internetowe, artykuły naukowe				
Supplementary reading	R. Durrer (2008): The Cosmic Microwave Background				
	Y. Wang (2010): Dark Energy				

STUDENT WORKLOAD

	No. of hours	
		W tym e-learning
Contact hours	40	0
Participation in test / exam	3	0
Preparation for contact hours	10	0
Private reading and studying	25	0
Participation in tutorials	20	0

Preparation of project / essay / etc.	25	0
Preparation for test / exam	2	0
TOTAL workload	125	
ECTS credits	5	

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-II-S-23/24Z-K							
Course title: Numerical and statistical methods in cosmology (numeryczne i statystyczne metody kosmologii)					Course code: SPR16AIIJ3445_57S		
Name of field of study: fizyka							
Mode and cycle of study: second degree, full - time			Profile of study: general academic		Specialty: kosmologia		
Course / module status obligatory				Language of instruction: semester: 2 - english language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
1	2	laboratory	30	0	pg	4	
Total			30			4	
Course / module coordinator		dr hab. VINCENZO SALZANO					
Course instructor		dr hab. VINCENZO SALZANO					
Course / module objectives		The aim of the course is to familiarize students with some of the methods of physics used to obtain (through reconstructions or statistics) information from experimental data. Students are able to analyze physical problems using general numerical methods written by themselves and are able to interpret the results.					
Prerequisites		Completed courses "Analysis of measurement data" and "Numerical methods"					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	Defines, describes and characterizes advanced numerical methods	K_W05 K_W06 K_W07			
skills	1	EP2	The student can infer physical information from experimental data using various numerical methods	K_U01 K_U03			
	2	EP3	The student can implement codes for numerical calculations	K_U02 K_U06			
	3	EP4	The student is able to compare the obtained results and assess the level of their credibility	K_U04 K_U10			
social competences	1	EP5	The student knows the limits of his own knowledge and understands the need for further education	K_K01 K_K02			
	2	EP6	The student can formulate precise questions to deepen his or her understanding of a topic or finding missing pieces of reasoning	K_K06 K_K07			
CONTENT					Semester	No. of hours	
						w tym e-learning	
Subject title: numeryczne i statystyczne metody kosmologii							
Format of instruction: laboratory							
1. Interpolation and extrapolation methods: fundamental algorithms; cubic spline function; LOESS/SIMEX algorithm					2	5	0
2. Gaussian processes (reconstruction methods)					2	3	0
3. Principal Component Analysis (PCA)					2	3	0
4. Bayesian Statistics: Monte Carlo Markov Chains (MCMC)					2	6	0
5. Nested sampling					2	5	0
6. Fast Fourier Transform					2	8	0

Modes of delivery	Lecture on the blackboard and with the use of a computer. Exercises conducted with the use of computers.				
Assessment methods					No. of learning outcome from the syllabus
	PREZENTACJA				EP1,EP2,EP3,EP4,EP5,EP6
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.				
Grading criteria	Verification by observation. Exercises: completion of the project.				
	Grade calculation principles				
	Mark from project 100%				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	2	numeryczne i statystyczne metody kosmologii		Ważona	
	2	numeryczne i statystyczne metody kosmologii [laboratorium]	zaliczenie z oceną		1,00
Basic reading	M. Hjorth-Jensen (2014): Computational Physics (Lecture Notes Fall 2014)				
	W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery (1997): Numerical Recipes in C				
	źródła internetowe, artykuły naukowe				
Supplementary reading					
STUDENT WORKLOAD					
			No. of hours		
			W tym e-learning		
Contact hours	30		0		
Participation in test / exam	5		0		
Preparation for contact hours	15		0		
Private reading and studying	15		0		
Participation in tutorials	15		0		
Preparation of project / essay / etc.	10		0		
Preparation for test / exam	10		0		
TOTAL workload	100				
ECTS credits	4				

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-II-S-23/24Z-K							
Course title: Physics of Black Holes (fizyka czarnych dziur)					Course code: SPR16AIJ3445_60S		
Name of field of study: fizyka							
Mode and cycle of study: second degree, full - time			Profile of study: general academic		Specialty: kosmologia		
Course / module status obligatory				Language of instruction: semester: 3 - english language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
2	3	konwersatorium	30	0	pg	5	
Total			30			5	
Course / module coordinator		dr HUSSAIN GOHAR					
Course instructor		dr HUSSAIN GOHAR					
Course / module objectives		Familiarizing students with the physics of black holes - thermodynamics, issues of statistical physics and quantum effects.					
Prerequisites		Compulsory: completion of the general theory of relativity course. Recommended: completion of the quantum field theory course.					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	The student will understand the the solutions of black holes in general relativity; thermodynamic and quantum phenomena related to black holes	K_W01 K_W02 K_W05 K_W06			
skills	1	EP2	The student will be able to solve the issues regarding thermodynamic, statistical and quantum processes related to black holes	K_U01 K_U04 K_U13			
social competences	1	EP3	Student will be ready to popularize science in the field of cosmology	K_K01 K_K05			
CONTENT					Semester	No. of hours	
							w tym e-learning
Subject title: fizyka czarnych dziur							
Format of instruction: konwersatorium							
1. Schwarzschild Solution, Reissner-Nordström Solution, Ker - Newman Solution, Coordinate Transformations and Penrose Diagrams					3	9	0
2. Hawking's Area Theorem, Bekenstein Entropy, Hawking Temperature, Laws of Black Hole Thermodynamics					3	9	0
3. Black Hole Entropy from Canonical Ensemble, Energy Fluctuations on the Horizon					3	3	0
4. Unruh Process, Hawking Process, Hawking Radiation as Quantum Tunneling, Black Hole Information Problem					3	9	0
Modes of delivery		conversational classes conducted using the application and problem method					

Assessment methods					No. of learning outcome from the syllabus
	PRACA PISEMNA/ ESEJ/ RECENZJA				EP1,EP2,EP3
Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.					
Grading criteria	Solving a selected project and a computational one and getting a positive grade from an essay summarizing it				
	Grade calculation principles				
	Final grade would be based on evaluation of assignments, the final project and presentation				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	3	fizyka czarnych dziur		Ważona	
	3	fizyka czarnych dziur [konwersatorium]	zaliczenie z oceną		1,00
Basic reading	S. Chandrasekhar (1998): The Mathematical Theory of Black Holes, Oxford University Press, Oxford				
	Andrei Zelnikov and V. Frolov (2013): Introduction to Black Hole Physics,, Oxford University Press, Oxford				
	(2009): Physics of Black Holes: A Guided Tour (Lecture Notes in Physics, 769), Springer				
	, Physical Review Letters				
	, Physical Review X				
	, Physical Review D				
	, Classical and Quantum Gravity, IOPscience				
Supplementary reading					
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	30		0		
Participation in test / exam	0		0		
Preparation for contact hours	25		0		
Private reading and studying	23		0		
Participation in tutorials	25		0		
Preparation of project / essay / etc.	22		0		
Preparation for test / exam	0		0		
TOTAL workload	125				
ECTS credits	5				

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-I-S-22/23Z							
Unit: Fizyka teoretyczna [moduł]							
Course title: Statistical Physics (fizyka statystyczna)					Course code: SPR16AIJ3445_41S		
Name of field of study: fizyka							
Mode and cycle of study: first-degree, full - time			Profile of study: general academic		Specialty:		
Course / module status elective				Language of instruction: semester: 4 - polish language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
2	4	konwersatorium	15	0	pg	2	
Total			15			2	
Course / module coordinator		dr hab. FRANCO FERRARI					
Course instructor		dr hab. FRANCO FERRARI					
Course / module objectives		The purpose of this course is to deepen the student's knowledge in the subject of statistical physics and its applications. The student should be able to use mathematical tools and the methods of statistical physics in order to describe physical phenomena and processes of systems containing a large number of particles, atoms or molecules. The students understands the necessity of further education and is ready to a critical evaluation of the received information.					
Prerequisites		knowledge of thermodynamics, quantum mechanics and theoretical mechanics. The student should have passed a course on the principles of thermodynamics and statistical physics					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	student pogłębia wiedzę w zakresie fizyki statystycznej, zna podstawowe pojęcia i prawa termodynamiki, potrafi opisać zjawiska i procesy na gruncie termodynamiki i fizyki statystycznej, potrafi rozwiązać analitycznie zagadnienia dla prostych układów kwantowych posługując się metodami fizyki statystycznej, posiada szczegółową wiedzę fizyczną w zakresie fizyki statystycznej	K_W11 K_W14 K_W20			
skills	1	EP2	Student potrafi posługiwać się aparatem matematycznym i metodami matematycznymi w opisie i modelowaniu zjawisk i procesów fizycznych, potrafi przygotować ustne wystąpienia w języku polskim i czytać ze zrozumieniem teksty naukowe.	K_U05 K_U19 K_U20			
social competences	1	EP3	Student rozumie potrzebę dalszego kształcenia się i jest gotów do krytycznej oceny docierających do niego informacji; student jest gotów pogłębiać własne zrozumienie danego tematu i odnaleźć brakujące elementy własnego rozumowania	K_K01 K_K02			
CONTENT					Semester		
					No. of hours		
					w tym e-learning		
Subject title: fizyka statystyczna							
Format of instruction: konwersatorium							
1. Classical statistical mechanics with applications to polymer physics					4	4	0
2. Bose-Einstein and Fermi-Dirac distributions					4	6	0

3. procesy stochastyczne		4	3	0	
4. prezentacja		4	2	0	
Modes of delivery	<p>theoretical classes consisting of a brief (about 30 minutes) introduction to a given subject followed by an hour of exercises on that subject..</p> <p>numerical exercises consisting of a brief (about 30 minutes) introduction to a given subject followed by two hours to solve numerical problems that are relevant to that subject.</p> <p>Presentation: Students will prepare as a homework a presentation on a subject of statistical physics that they find particularly interesting and will present it during the lectures.</p>				
Assessment methods			No. of learning outcome from the syllabus		
	KOLOKWIUM		EP1,EP2		
	PREZENTACJA		EP1,EP3		
	ZAJĘCIA PRAKTYCZNE (WERYFIKACJA POPRZEZ OBSERWACJĘ)		EP3		
Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.					
Grading criteria	<p>ćwiczenia: zaliczenie kolokwium</p> <p>prezentacja: jakość odpowiedzi na pytania, które odbędą się po przedstawieniu prezentacji</p>				
	Grade calculation principles				
	<p>$OC=OK*80 + OP*20$</p> <p>gdzie</p> <p>OC=ocena końcowa</p> <p>OK=ocena z kolokwium</p> <p>OP= ocena z prezentacji</p>				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	4	fizyka statystyczna		Nieobliczana	
	4	fizyka statystyczna [konwersatorium]	zaliczenie z oceną		
Basic reading	Franco Ferrari : slajdy i notatki wstępów umieszczone na stronie internetowej przedmiotu				
	Kerson Huang (2006): Podstawy Fizyki Statystycznej, Wydawnictwo Naukowe PWN, Warszawa				
Supplementary reading					
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	15		0		
Participation in test / exam	2		0		
Preparation for contact hours	4		0		
Private reading and studying	6		0		
Participation in tutorials	8		0		
Preparation of project / essay / etc.	6		0		
Preparation for test / exam	9		0		
TOTAL workload	50				
ECTS credits	2				

COURSE SYLLABUS AND SPECIFICATION

Curriculum title: USSPR-F-O-II-S-23/24Z-K							
Course title: Alternative cosmological scenarios (alternatywne scenariusze kosmologiczne)					Course code: SPR16AIJ3445_62S		
Name of field of study: fizyka							
Mode and cycle of study: second degree, full - time			Profile of study: general academic		Specialty: kosmologia		
Course / module status obligatory				Language of instruction: semester: 4 - english language			
Year	Semester	Form of instruction	No. of hours		Type of credit	ECTS	
				w tym e-learning			
2	4	konwersatorium	30	0	pg	5	
Total			30			5	
Course / module coordinator		dr hab. VINCENZO SALZANO					
Course instructor		dr hab. VINCENZO SALZANO					
Course / module objectives		The aim of the course is to familiarize students with the main theoretical achievements of modern cosmology related to theories of gravity. Upon completion of the course, students have a general understanding of the state of theoretical cosmology.					
Prerequisites		Completed courses on "General Theory of Relativity" (optional), "Elements of Cosmology" (optional), "Theory of gravity" (optional)					
LEARNING OUTCOMES							
Category	No.	Code	Description	Ref. to programme benchmarks			
knowledge	1	EP1	The student knows the main research methods and directions of modern theoretical cosmology	K_W01 K_W02 K_W05			
skills	1	EP2	understands the relationship between local astronomical and astrophysical quantities with evolution of the universe on cosmological scales	K_U01 K_U02			
	2	EP3	The student discusses and works in a team and maintains openness to the arguments of others	K_U03 K_U07			
social competences	1	EP4	The student knows the limitations of his own knowledge and understands the need further education	K_K01 K_K06			
	2	EP5	The student can formulate questions with precision, deepen his own understanding of the topic or finding missing pieces of reasoning	K_K05			
CONTENT					Semester	No. of hours	
						w tym e-learning	
Subject title: alternatywne scenariusze kosmologiczne							
Format of instruction: konwersatorium							
1. Overview of General Relativity					4	3	0
2. Observational motivations for alternative gravity models					4	2	0
3. Classification of alternative gravity models					4	1	0
4. Screening mechanisms					4	2	0
5. Alternative gravity models with additional fields					4	6	0

6. High derivatives and nonlocal theories		4	6	0	
7. Multi-dimensional theories		4	6	0	
8. Observational constraints on alternative gravity models		4	4	0	
Modes of delivery	Lectures made using computer presentation and discussion of scientific articles				
Assessment methods				No. of learning outcome from the syllabus	
	EGZAMIN USTNY			EP1,EP2,EP3,EP4,EP5	
	Metody i formy weryfikacji efektów uczenia się mogą zostać zmienione dla studentów ze szczególnymi potrzebami na warunkach i zasadach określonych w Regulaminie Studiów Uniwersytetu Szczecińskiego.				
Grading criteria	Oral test: answering questions or presenting a project.				
	Grade calculation principles				
	Mark from oral exam				
Final grade calculation method	Sem.	Course	Type of credit	Grade calc. method	Weight for the average
	4	alternatywne scenariusze kosmologiczne		Ważona	
	4	alternatywne scenariusze kosmologiczne [konwersatorium]	zaliczenie z oceną		1,00
Basic reading	M. Ishak (2019): Testing general relativity in cosmology				
	T. Clifton, P. G. Ferreira, A. Padilla & C. Skordis (2012): Modified gravity and cosmology				
	źródła internetowe, artykuły naukowe				
Supplementary reading					
STUDENT WORKLOAD					
		No. of hours			
		W tym e-learning			
Contact hours	30		0		
Participation in test / exam	5		0		
Preparation for contact hours	20		0		
Private reading and studying	23		0		
Participation in tutorials	22		0		
Preparation of project / essay / etc.	10		0		
Preparation for test / exam	15		0		
TOTAL workload	125				
ECTS credits	5				