UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Fisica e Chimica - Emilio Segrè
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	PHYSICS
SUBJECT	HIGH ENERGIES ASTROPHYSICS WITH LABORATORY
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20901-Attività formative affini o integrative
CODE	22020
SCIENTIFIC SECTOR(S)	FIS/05
HEAD PROFESSOR(S)	IARIA ROSARIO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	86
COURSE ACTIVITY (Hrs)	64
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**IARIA ROSARIO** Wednesday 15:00 17:00 Dipartimento di Fisica e Chimica - Via Archirafi 36- secondo piano - stanza 204 Friday 15:00 17:00 Dipartimento di Fisica e Chimica - Via Archirafi 36- secondo piano - stanza 204

DOCENTE: Prof. ROSARIO IARIA

PREREQUISITES	This is a teaching in the second year of the Master's Degree Course in Physics, so the prerequisites to profitably follow the teaching and achieve its objectives are the knowledge of mathematics and physics required for enrollment in the Master's Degree Course in Physics and elements of radiation-matter interaction
LEARNING OUTCOMES	Knowledge and understanding skills: The student should know about compact objects. The dynamics of an X-ray binary system and the physics of an accretion disk. In addition he/she must know the spectral components that each element of the X binary system produces; blackbody emission from the surface of the neutron star, "multi-temperature" blackbody emission from an accretion disk, Compton emission from a plasma cloud around the neutron star. Finally, the student should know the production mechanisms that form cyclotron resonance scattering features (CRSF) and relativistically broadened emission lines produced in accretion disks. Degeneracy pressure in compact objects, radio pulsars and the recycling scenario, orbital evolution of a binary system. Ability to apply knowledge and understanding: The student should know how to use and apply the methods (expounded in the course) of classical mechanics and electrodynamics, as well as elementary concepts of special and general relativity and quantum mechanics that originate the spectral characteristics of an X-ray binary system and that enable the study of the time evolution of an X-ray binary system. Autonomy of judgment: The student should know how to rigorously and critically analyze the fundamental aspects of a problem concerning X-ray binary systems containing neutron star or black hole and solve it independently. Communication skills: The student should be able to enucleate, focus and expose the essential aspects of a specific problem concerning the dynamical and emission processes present in an X-ray binary system. Learning skills: The student should be able to independently investigate in-depth topics concerning the evolution and emission of an X binary system.
ASSESSMENT METHODS	The final examination consists of an oral test in which they discuss two papers they wrote on the laboratory activities carried out (spectral analysis and time analysis of a NS-LMXB system). The oral test consists of an examination-interview concerning the statement and discussion of the physical laws studied and their application. This test makes it possible to assess, in addition to the candidate's knowledge and ability to apply it, the possession of scientific language properties and clear and direct exposition skills. The final assessment, appropriately graded, will be made on the basis of the following conditions: (a) Basic knowledge of the physical laws studied and limited ability to apply them independently to situations similar to those studied, sufficient ability to analyze the phenomena presented and exposition of reasoning (grade 18-21); (b) Good knowledge of the physical laws studied and ability to apply them independently to situations similar to those studied, fair ability to analyze the phenomena presented and exposition of reasoning (grade 22-25); (c) Thorough knowledge of the physical laws studied and ability to apply them to each physical phenomenon proposed, but not always readily and following a linear approach, good ability to analyze the phenomena presented and exposition of reasoning (grade 26-28); (d) Thorough and widespread knowledge of the physical laws studied and ability to apply them readily and correctly to each proposed physical phenomenon, excellent ability to analyze the phenomena presented and excellent communication skills (grade 29-30L).
EDUCATIONAL OBJECTIVES	The training objective of this teaching is to give students a master-degree level knowledge of a X-ray binary systems hosting a neutron star or a black hole. The student learns how a binary system evolves acquiring knowledge of the main mechanism causing the lost of angular momentum: emission of gravitational waves, magnetic breaking and mass transfer. Furthermore the student learns the physical mechanisms giving rise to the main energy spectral features observed in X-ray binary systems (e.g. CRSFs, Comptonised spectra, smeared relativistic emission lines). Finally, the student learns the physics laws ruling the accretion disc and the interactions between the neutron star magnetic field and the accretion disc.

TEACHING METHODS	Teaching is semester-long. The teaching activity is developed through 32 hours of face-to-face lectures in which the lecturer illustrates the various topics that are part of the teaching program plus 32 hours of laboratory activities in which students consolidate their knowledge of part of the topics discussed during the face-to-face lectures, maturing the ability to interconnect the different topics covered.
SUGGESTED BIBLIOGRAPHY	BASIC TEXTBOOK J. FRANK, A. KING , D. RAINE Accretion Power in Astrophysics ISBN: 9781139164245 BASIC TEXTBOOK M.S. LONGAIR High Energy Astrophysics 3rd Edition ISBN: 9780521756181

SYLLABUS

Hrs	Frontal teaching
4	Physics of the compact objects: The degeneracy pressure. White dwarfs, neutron stars, black holes.
5	Kepler's law, close and open orbits, Roche lobes, relations between orbital parameters and angular momentum of the binary system
5	Accretion discs: alpha discs, spectral emission from a disc
4	HMXBs and LMXBs
6	Formation and evolution of Low Mass X-ray binary systems
8	Energy spectra of HMXBs and LMXBs: study of the main spectral features

Hrs	Workshops
16	Timing analysis of a X-ray NS-LMXB
16	Spectral analysis of a X-ray NS-LMXB