UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Fisica e Chimica - Emilio Segrè
ACADEMIC YEAR	2018/2019
MASTER'S DEGREE (MSC)	PHYSICS
INTEGRATED COURSE	COMPLEX NETWORKS
CODE	19764
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	FIS/07
HEAD PROFESSOR(S)	MANTEGNA ROSARIO NUNZIO — Professore Ordinario — Univ. di PALERMO
OTHER PROFESSOR(S)	MANTEGNA ROSARIO NUNZIO — Professore Ordinario — Univ. di PALERMO MICCICHE' SALVATORE — Professore Ordinario — Univ. di PALERMO
CREDITS	6
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**MANTEGNA ROSARIO NUNZIO** Tuesday 15:00 17:00 Studio del docente presso l'Edificio 18 di Viale delle Scienze previa comunicazione email all'indirizzo rosario.mantegna@unipa.it Professor's office located at Building 18 in Viale delle Scienze upon previous email agreement to rosario.mantegna@unipa.it **MICCICHE' SALVATORE** Tuesday 15:00 17:00 Dipartimento di Fisica e Chimica, Viale delle Scienze, Ed. 18, Studio del docente. Gli studenti sono pregati di iscriversi tramite portale UNIPA. \\ Department of Physics and Chemistry, Viale delle Scienze, Ed. 18, Lecturer's office. Students are requested to register through the UNIPA portal.

DOCENTE: Prof. ROSARIO NUNZIO MANTEGNA

PREREQUISITES	Knowledge of a programming language.
LEARNING OUTCOMES	Knowledge and ability to understand - Acquisition of the basic concepts of complex networks Ability to apply knowledge and understanding - Ability to apply the fundamental concepts to the study of model complex systems. Autonomy of judgment - The course stimulates a critical approach to the learning of concepts and in the solution of complex networks problems, also taking into account computational issues. Communicative skills - Students are invited to interact during the lesson, exposing their evaluation and their opinion about the considered topic, also taking into account computational issues. Learning skills - The autonomous approach of the student is stimulated in the search for theoretical and computational solutions best suited for the representation and study of model and real complex networks. All student's skills are carefully evaluated during the exam.
ASSESSMENT METHODS	The final assessment consists of a written/practical test followed by an oral test. The written test has two part. In the first part the student will perform, without the aid of textbooks or notes, a resolution of problems and/or will answer questions concerning concepts of Complex Networks. In the second part, carried out in the computer room, the student will write a code for a quantitative description of a complex network. The written examination will verify the degree of knowledge of complex network concepts. In particular, the exam will highlight student's ability to analyze networks and to obtain quantitative results. The oral exam consists of an interview about the enunciation and discussion of topics developed during the course and in the resolution of problems proposed to the candidate. This test makes it possible to evaluate not only the candidate's knowledge and his ability to apply it, but also the control of scientific language and of clear and direct exposure skills. The final grade will be obtained by averaging the assessments of the written and oral tests. It will be formulated on the basis of the following conditions: a) Basic knowledge of the models and applications of complex networks studied and limited capacity to apply them autonomously, sufficient capacity for analysis of the presented phenomena and of the exposure of the procedures followed (vote 18-21); b) Good knowledge of the models and applications of studied complex networks and ability to apply them autonomously to situations similar to those studied, discrete capacity for analysis of the phenomena presented and for the exposure of the procedures followed (grade interval 22-25); c) In-depth knowledge of the models and applications of studied complex networks and the ability to apply them to unknown conditions, even with some hesitation, good ability to analyze the presented phenomena and to show the procedures followed (grade interval 26-28); d) In-depth and widespread knowledge of the models and applications of studied complex networks and ability to apply them promptly and correctly to unknown complex networks, excellent ability to analyze the phenomena presented and excellent communication skills (grade interval 29-30L).
TEACHING METHODS	The course is given during one term and includes both classroom lectures and lectures in the Computer Classroom. The teaching activity is developed through lessons and numerical/practical exercises in which problems are solved, which aim to test student's skills to apply the acquired knowledge.

MODULE
COMPLEX NETWORKS MODELS

Prof. ROSARIO NUNZIO MANTEGNA

SUGGESTED BIBLIOGRAPHY

Testo di riferimento:
- Newman, M., 2010. Networks: an introduction. Oxford university press.

Testi consigliati per approfondimenti:
- Barabasi, A.L. and Posfai, M., 2016. Network science. Cambridge university press.
- Latora, V., Nicosia, V. and Russo, G., 2017. Complex networks: principles, methods and applications. Cambridge University Press.

AMBIT	20901-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	51
COURSE ACTIVITY (Hrs)	24

EDUCATIONAL OBJECTIVES OF THE MODULE

The teaching unit aims to introduce students to the main models of complex networks. In particular we will discuss: The Erdos-Renyi model, the small world model, the core periphery model, the scale free network model and the group of models called exponential random graphs. We will briefly discuss the concept (i) of "configuration model", (ii) of resilience of a network to attacks or malfunctions, and (ii) of diffusion on a network. The objective is to familiarize students with models of complex networks and to realize under what conditions the cited models approximate real networks.

SYLLABUS

Hrs	Frontal teaching
2	Introduction: Examples of complex networks. Internet and the World Wide Web. Network science as a multidisciplinary approach. The concepts of feedback, hierarchical organization, and emergence.
2	Percolation on lattices. Disordered systems. Phase transition in percolation. The Cayley tree.
2	Complex networks. Basic indicators of a network. Degree, betweenness, clustering coefficient, diameter.
2	Visualization and measuring of network indicators. Introduction to some computer tools to visualize and to measure network metrics.
2	The first example of a complex network. The Erdős-Rényi (ER) graph and its properties. Percolation transition in the ER model.
2	Small world model. The Milgram experiment and its contemporary version. “Six degrees of separation”. Distance and clustering coefficient in a small world network.
2	Scale free network. Network growth in the presence of preferential attachment. Mean field solution of a scale free network. Some variants of the basic model.
2	Core-periphery structure. Maximum entropy for network construction. The approach of minimum density. A real example: The interbank market
2	The class of models "exponential random graphs". The two-star model. Stauss’s model. A time dependent model of network formation. Hysteresis in network dynamics.
2	the so-called "Configuration model". The concept of a null model with given degree distribution and its properties. General problem of null models. The rewiring approach.
2	Robustness and vulnerability of a network. Random failures and intentional attacks. Vulnerability of different classes of networks. Resilience of classes of networks.
2	Diffusion on networks. The SI (susceptible infected) and SIR (susceptible infected recovered) models in epidemiology. Models of epidemics on networks. The problem of the diffusion of innovation.

MODULE COMPLEX NETWORKS APPLICATIONS *Prof. SALVATORE MICCICHE'*	
SUGGESTED BIBLIOGRAPHY	
Materiale fornito dal docente./Material provided by the lecturer. Testi di Consultazione/Reference books: - Newman, M., 2010. Networks: an introduction. Oxford University Press. ISBN: 9780198805090. - Barabasi, A.L. and Posfai, M., 2016. Network science. Cambridge University Press. ISBN: 978-0199206650. - Latora, V., Nicosia, V. and Russo, G., 2017. Complex networks: principles, methods and applications. Cambridge University Press. ISBN: 978-1107103184	
AMBIT	20901-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	51
COURSE ACTIVITY (Hrs)	24
EDUCATIONAL OBJECTIVES OF THE MODULE	
The aim of the course is to provide the basic knowledge for the generation and analysis of complex networks and their partitioning into communities.	

SYLLABUS

Hrs	Frontal teaching
2	Introduction to the course. Adjacency lists and calculation of network metrics.
2	Generation according to Erdős-Rényi and small-world models and analysis of networks with fixed-scale degree distribution.
2	Generation according to the core-periphery models and preferential attachment and analysis of networks with scale-free degree distribution.
2	Networks visualisation.
2	Implementation of the SIR model.
4	Community detection algorithms.
2	Applications of community detection algorithms to model complex systems.
2	Configuration model.
2	Rewiring techniques.
2	Statistically validated networks.
2	Correlation based networks