PH2821 Applications of statistical physics to complex socio-economical systems

Professor : Gregory SCHEHR

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : Basic probability theory. Programming in either MATLAB, C/C++, Python or R

Period : S8 elective 10 between february and june

Course Objectives

Provide an understanding of the fundamental concepts of statistical physics, and their application to the study of diverse complex systems in natural and socio-economical environments, which share the characteristics of competition for resources among interacting agents and their adaptation to dynamically changing environments.

The course will explore some very elegant, thought-provoking and intriguing models, tools and analyses in the studies of complex systems, inspired by ideas and concepts in statistical physics. The students will learn how to conduct numerical laboratory experiments and simulations of complex systems, and ways to tackle related problems (both individually and in teams).

On completion of the course, students should be able to

Understand the theoretical concepts of:

- basics of statistical physics and its inter-disciplinary applications
- complex systems and difficulties in handling them
- multi-agent based modeling and its advantages
- random networks and their applications

Emphasis will be laid on developing presentation skills, working individually (with original ideas) and working in a collaborative team as well.

Course Contents

Statistical physics has been defined as that "branch of physics that combines the principles and procedures of statistics with the laws of both classical and quantum mechanics, particularly with respect to the field of thermodynamics. It aims to predict and explain the measurable properties of macroscopic (bulk) systems on the basis of the properties and behaviour of their microscopic constituents. The term "complex systems" was coined to cover the wide-ranging variety of such systems which include examples from physics, chemistry, biology, computer science and also social sciences. The concepts and methods of statistical physics proved to be extremely useful in application to these diverse complex systems, many of which involve many competing agents. The understanding of the global behaviour of complex systems seems to require such concepts as stochastic dynamics, correlation effects, self-organization, self-similarity and scaling, theory of networks and combinatorial optimization, and for their application it is not necessary to go into the detailed "microscopic" description of the complex system.

The students gain knowledge about:

- Basics of statistical physics and complex systems
- Study of socio-economic networks
- Random networks
- Multi-agent modeling: kinetic-exchange and game-theoretical

The classes are divided into two forms: (a) theoretical (lectures) and (b) practical (programming exercises and projects). During lectures, the basic theory and the recent trends will be presented by the instructor. In the practical classes, students will be assigned to groups and will work on lab exercises and projects. The practical classes, supervised by an assistant, will mainly consist of implementing some standard algorithms described during the lectures and aim at consolidating the theoretical techniques described in class. Also, simple projects will be allotted to small teams, where some notions of the theoretical part will need to be applied and implemented. The project will enable the candidate to conduct some independent work as well as team activities. The implementation may be done either in MATLAB, C/C++, Python or R.

Course Organization

Lectures: 14 hr, Tutorials: 3 hr, Labwork: 15 hr, Exams: 4 hr

Bibliography / Teaching Material and Textbooks

Presentations and supplementary materials will be uploaded on the website at the end of every lecture. No course reader provided.

Resources

Lecturers: Grégory Schehr (CNRS, Univ. Paris-Sud, LPTMS), Kevin Primicerio (Chaire de finance quantitative, Labo. M. A. S.), Marcus Cordi (Chaire de finance quantitative, Labo M.A.S).

Evaluation

Labwork and group project with oral defense: 75%, 1-hr mid-term written exam (mandatory): 25%.