UNIVERSITÀ DEGLI STUDI DI PALERMO

DIPARTIMENTO DI FISICA E CHIMICA - DiFC

Direttore: prof.ssa Stefana Milioto

La Fisica Computazionale al DIFC

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14 Maggio 2021.
L'evento si svolgerà in modalità telematica tramite la piattaforma Microsoft Teams sul team di codice: yurh7d2

G. Peres, F. Reale, B. Spagnolo, D. Valenti, R.N. Mantegna, F. Musciotto, D. Miccichè, G. Cottone.
Dipartimento di Fisica e Chimica – Emilio Segré, Università degli Studi di Palermo

During this talk, born from the collaboration with ***Associazione Studentesca Vivere Scienze MM.FF.NN***., several topics regarding the research in Computational Physics that take place in the Department of Physics and Chemistry - Emilio Segré (DIFC) are going to be presented.
The participation at the event will give the possibility to accumulate 3.5 hours for “Altre conoscenze utili per l’inserimento nel mondo del lavoro” (Others formative activities).

Follow the titles of each talk and their relative abstracts.

The numeric experiment in Sun's Physics
Professor Fabio Reale

The Sun is the only star we can study closely. It is therefore, a very precious model for understanding the others, much more distant, stars. The Sun is also a valuable place where several physical processes develop under extreme conditions. Very low density and very high temperature plasmas interact strongly with the magnetic field, releasing energy even in explosive form through magnetic reconnection. The investigation of these processes is difficult and numerical simulations become an indispensable tool as them become increasingly sophisticated with the evolution of information technology.

Models of the birth of the stars and of their explosive end
Professor G. Peres.

Numerical models are an essential tool for understanding some phases of the stellar evolution: from their formation from an accretion disk to their end in a Supernova explosion, for the most massive ones. Some models of stellar formation as well as of the interaction of the stellar explosion with the circumstellar medium allow us to understand the complex physical effects that characterize these phenomena. Moreover such models allow us to explain some experimental facts that are otherwise difficult to understand. The simultaneous interaction of the various physical effects and the non-linearity of the complex differential equations necessary to describe them makes the development of these models a formidable challenge. In some cases them can go so far to allow us to make predictions on the evolution of these phenomena. Over the years such predictions have been validated by new observations.
The need for huge computing resources, obtainable only on a competitive basis within European tenders, places these scientific projects among the most ambitious on an international level.

The Complex Systems Physics
Professor Bernardo Spagnolo.

The research activity conducted by the *Interdisciplinary Theoretical Physics Group* is related to Non-Equilibrium Statistical Mechanics and Complex Systems Physics. In particular, our research activity focuses on the role of environmental noise in various out-of-equilibrium physical systems, both classical, quantum, and biological, and is carried out through the use of theoretical techniques of non-equilibrium statistical mechanics. The main lines of research of the group are:
- Effects Induced by Noise in Complex Systems far from equilibrium;
- Quantum Phase Transitions and Topological Phenomena in Condensed Matter;
- Majorana Fermions;
- Multiparametric Critical Quantum Metrology.

Stochastic Modeling for Complex Systems in Physics and Interdisciplinary Contexts
Dottor Davide Valenti

We present three examples of complex systems modeled by stochastic differential equations: i) a Josephson junction used as a possible detector, in a noisy background, for Lévy distributed fluctuations [1]; ii) a two-dimensional marine ecosystem consisting of four phytoplankton populations, whose spatio-temporal distributions are obtained by using a 2D stochastic advection-reaction-diffusion model [2, 3]; iii) a real financial market whose dynamics is described by a nonlinear Heston model [4]. In the first system, the cumulative distribution function of the switching currents are obtained by numerically solving the resistively and capacitively shunted junction model for the dynamics of the phase difference through the junction. The cumulative distribution exhibits a clear dependence on the stability index α of the Lévy noise source: measuring the switching current distribution therefore allows to retrieve information on the statistical properties of Lévy noise sources. In the second system, the chlorophyll a distributions, obtained by numerically solving the stochastic advection-reaction-diffusion model, are compared with field data collected in twelve marine sites of southern Mediterranean Sea. The results agree with field data better than theoretical distributions previously calculated by the corresponding deterministic model. The last system, which reproduces the behaviour of a financial market through a nonlinear Heston model, is studied by using the mean first hitting time as an indicator of price stability. In an empirical analysis of daily returns for 1071 stocks traded in the New York Stock Exchange, one finds that this measure of stability displays non monotonic behavior, with a maximum, as a function of volatility. This behaviour is well reproduced by the proposed nonlinear Heston model, solved by numerical methods.

[1] C. Guarcello, DV, B. Spagnolo, V. Pierro, and G. Filatrella, *Josephson-based threshold detector for Lévydistributed current fluctuations*, Phys. Rev. App. 11, 044078 (2019).
[2] DV, G. Denaro, B. Spagnolo, S. Mazzola, G. Basilone, F. Conversano, C. Brunet, A. Bonanno, *Stochastic models for phytoplankton dynamics in Mediterranean Sea*, Ecol. Complex. 27, 84 (2016).
[3] DV, G. Denaro, R. Ferreri, S. Genovese, S. Aronica, S. Mazzola, A. Bonanno, G. Basilone, B. Spagnolo, *Spatiotemporal dynamics of a planktonic system and chlorophyll distribution in a 2D spatial domain: matching model and data*, Sci. Rep. 7, 220 (2017).
[4] DV, G. Fazio, B. Spagnolo, *Stabilizing effect of volatility in financial markets*, Phys. Rev. E 97, 062307 (2018).

Research activities of the Complex Systems Observatory
Professor Rosario Nunzio Mantegna

A brief illustration on the main lines of research investigated in recent years by the *Complex Systems Observatory* will be presented. In in particular, the talk will focus on the research on the process of aggregation of information in biological, economic and social systems and on their relationships with statistical physics issues.

Filtering techniques in complex networks
Doctor Federico Musciotto

Complex networks allow us to describe a broad variety of biological and socio-technical systems, in which their agents are described as nodes and their interactions as links. The explosion of the amount of data available in recent decades on such systems has also made evident the need to implement techniques of statistical validation that identify which connections are significant and filter those compatible with random processes. During the talk an excursus of these techniques will be presented trough the description of their principles basics and some of their applications.

Empirical analysis and computational models in social and socio-technical complexes
Professor Salvatore Miccichè

Some theoretical-computational methodologies, typically used in the study of complex systems, will be illustrated. In particular, two complex model systems will be considered. One, of social nature, made up of a set of subjects who have suffered convictions for organized crime offenses, and the other, of socio-technical nature, consisting of the air transport system.

The Computational Biophysics
Professor Grazia Cottone

Computational biophysics deals with the study of the structure, the dynamics and the function of biological matter, with a physical approach that make intensive use of the computer. In this talk particular emphasis will be given to the study of proteins in solvent through the method of "Molecular Dynamics", a numerical technique that allows to study equilibrium and transport properties of systems with a high number of particles, taking advantage of high-performance computing systems.