

NONLINEAR SCIENCE AND COMPLEXITY

Pescara, 28 – 31 July, 2009

INTERNATIONAL CONFERENCE Organized by:

Dipartimento di Metodi Quantitative e Teoria Economica

Università "G. d'Annunzio" Chieti-Pescara

ABSTRACTS

(in alphabetical order of speakers)

IN SILICO INVESTIGATION OF PROTEIN-PROTEIN NETWORKS COMPLEXITY

Anastasios Bezerianos, BS, MS, PhD

Biosignal Processing Laboratory, Department of Medical Physics,
School of Medicine, University of Patras, Rio, 26500, Greece.

The study of biological networks is playing an ever increasing role in our quest of understanding regulatory mechanisms in cells and diseases at a system level. The last decade surge in biotechnologies resulted in extensive genome and proteome-wide databases. The more the experiments the higher the complexity of the biological networks. Be it genes regulation, protein interaction networks reconstruction, or even basic data processing, there is an acute need for computational methods and mathematical models able to provide an integrative approach suitable for the amount and types of existing data. The current work aims at reviewing our approach to the named challenges and describes several of the computational methods developed recently within our research group to simplify the biological networks complexity.

ENERGY LOCALIZATION ON Q--TORI, NEKHOROSHEV STABILITY AND THE INTERPRETATION OF FPU RECURRENCES

Tassos Bountis¹, Helen Christodoulidi¹ and C. Efthymiopoulos²

¹Department of Mathematics and Center for Research and Applications of Nonlinear Systems (CRANS), University of Patras

²Research Center for Astronomy and Applied Mathematics, Academy of Athens

Two approaches have been proposed in recent years for the explanation of the so-called FPU paradox, i.e. the persistence of energy localization in the 'low-q' Fourier modes of Fermi--Pasta--Ulam nonlinear lattices, preventing equipartition among all modes at low energies. In the first approach, a low-frequency fraction of the spectrum is initially excited leading to the formation of 'natural packets' exhibiting exponential stability, while in the second, emphasis is placed on the existence of 'q--breathers', i.e. periodic continuations of the linear modes of the lattice, which are

exponentially localized in Fourier space. Following ideas of the latter, we introduce in this paper the concept of 'q-tori' representing exponentially localized solutions on $\{n\text{-dimensional tori}\}$ and use their stability properties to reconcile these two approaches and provide a more complete explanation of the FPU paradox.

INFORMATION GEOMETRY OF REGIME-SWITCHING MODELS

Angela De Sanctis

University "G. d'Annunzio" of Chieti-Pescara

We discussed the possibility to give a geometrical interpretation of stochastic dynamical systems in which the motion randomly switches between two regimes using Markovian transitions. For a regime-switching model of the price behavior with time-varying parameters, using Information Geometry, we proved that the space of the conditional probability distributions is an exponential family which depend by an hidden variable varying with the information at the previous time. When this information is not fixed, we obtain a network trained by various input signals and corresponding output behaviors, as in the neural case. In particular the (EM) and (em) Algorithms are equivalent.

DETECTION AND ANALYSIS OF REGIME-SWITCHING MODELS WITH TOOLS DERIVED FROM INFORMATION GEOMETRY

Demetris P.K. Ghikas

Department of Physics, University of Patras, Patras 26500, Greece

We first present a short introduction to regime-switching models and methods of analysis of the related questions. Then we formulate a possible information geometric framework to approach the problem of detection of regime-switching in a given time-series. We present some preliminary results, and discuss ways to improve the geometric tools.

FRONTIERS IN COMPLEX SYSTEMS RESEARCH

G. Nicolis

Center for Nonlinear Phenomena and Complex Systems (CENOLI)
Université Libre de Bruxelles

Complexity research addresses in a novel way and from a unifying point of view a wide spectrum of problems of concern at the crossroads of physical, engineering, environmental, life and social sciences. In this lecture the foundations of research on complex systems are outlined, with emphasis on open issues and on challenges lying ahead.

STABLE CHAOS

Antonio Politi

CNR-Istituto dei Sistemi Complessi

Systems with many degrees of freedom can exhibit exponentially long and irregular transients that are linearly stable. For several years it was believed to be a sort of mathematical curiosity due to the presence of discontinuities in the evolution equations of high-dimensional dynamical systems. More recently, it has become clear that it is more general than expected and may even have some relevance in connection to information processing in neural networks. I will review the key methods to identify and characterize "stable chaos".

STATISTICAL MECHANICS AND DYNAMICS OF SOLVABLE MODELS WITH LONG-RANGE INTERACTIONS

Stefano Ruffo

Dipartimento di Energetica "S. Stecco", Università di
Firenze, and INFN.

Systems with long-range interactions, like gravitational, charged and dipolar systems, can be made extensive, but are intrinsically non additive. The violation of this basic property of thermodynamics is the origin of ensemble inequivalence, which in turn implies that specific heat can be negative in the microcanonical ensemble, temperature jumps can appear at microcanonical first order phase transitions, ergodicity may be broken. Realizing that such features may be present for a wide class of systems has renewed the interest in long-range interactions. In this seminar, I will present a review of the recent advances on the statistical mechanics and out-of-equilibrium dynamics of solvable models with long-range interactions.

SPREADING OF WAVE PACKETS IN ONE DIMENSIONAL DISORDERED CHAINS

Charalampos (Haris) Skokos

Max Planck Institute for the Physics of Complex Systems,
Nöthnitzer Str. 38, D-01187 Dresden, Germany

Abstract

We study the spreading of wave packets in quartic Klein-Gordon (KG) and disordered nonlinear Schrödinger (DNLS) chains, having equivalent linear parts. In the absence of nonlinearity all eigenstates are spatially localized with an upper bound on the localization length (Anderson localization). In the presence of nonlinearity we predict theoretically and verify numerically the existence of three different dynamical behaviors depending on the relation of the nonlinear frequency shift δ (which is proportional to the system's nonlinearity) with the average spacing $\overline{\Delta\lambda}$ of eigenfrequencies and the spectrum width Δ ($\overline{\Delta\lambda} \leq \Delta$) of the linear system. The dynamics for small nonlinearities ($\delta < \overline{\Delta\lambda}$) is characterized by localization as a transient, with subsequent subdiffusion (regime I). For intermediate values of the nonlinearity, such that $\overline{\Delta\lambda} < \delta < \Delta$ the wave packets exhibit immediate subdiffusion (regime II). In this case, the second moment m_2 and the

participation number P increase in time following the power laws $m_2 \sim t^\alpha$, $P \sim t^{\alpha/2}$. We find $\alpha=1/3$. Finally, for even higher nonlinearities $\delta > \Delta$ a large part of the wave packet is selftrapped, while the rest subdiffuses (regime III). In this case P remains practically constant, while $m_2 \sim t^\alpha$. In particular, we present numerical results for the spatiotemporal evolution of single site, single mode and general finite size excitations. We also give details on the used symplectic integration schemes, and perform extensive tests which demonstrate that the observed effects are not affected by roundoff errors.

References

1. S. Flach, D. O. Krimer and Ch. Skokos, *Universal Spreading of Wave Packets in Disordered Nonlinear Systems*, Phys. Rev. Lett. **102**, 024101 (2009).
2. Ch. Skokos, D. O. Krimer S. Komineas and S. Flach, *Delocalization of Wave Packets in Disordered Nonlinear Chains*, Phys. Rev. E **79**, 056211 (2009).

A MILP MODEL FOR THE MEDIUM-TERM RESOURCE SCHEDULING PROBLEM OF A LARGE DIMENSION POWER PRODUCER

M.T. Vespucci, M. Innorta, D. Siface
University "G. d'Annunzio" of Chieti-Pescara

A model for the medium-term resource scheduling problem of a power producer of large dimension is introduced, that maximizes the producer market share while guaranteeing a minimum pre-assigned profit level and satisfying technical constraints. The nonlinearities, introduced into the model by representing the power producer influence on hourly zone equilibrium prices and quantities, are linearized by means of binary variables. A case study related to the Italian electricity market is discussed.