SAPIENZA
UNIVERSITÀ DI ROMA

Dipartimento di Fisica, Sapienza Università di Roma (Aula Conversi)

Mathematical Physics: Theory and Applications

Conference in honour of Brunello Tirozzi seventieth birthday

Rome, September 18-20 2014

list of Abstracts

Speaker: **SERGIO ALBEVERIO, Institute for Applied Mathematics, Bonn University (GE)**
Title: TBA

Abstract: TBA

Speaker: **ALESSANDRO CARDINALI, Associazione Euratom, ENEA, Frascati (IT)**
Title: **Asymptotic techniques in the solution of the Maxwell's equations in plasmas**

Abstract: In a plasma (with or without an external magnetic field) the propagation of the electromagnetic modes from low (Radio Waves) to high frequencies (TeraHertz) is described via the Maxwell's equation system coupled to the plasma dynamics that can be modeled by the Vlasov's equation. Although a fluid description in the plasma dynamics simplifies considerably the theory, a global solution would still be excluded due to the complexity of the matter. In some relevant conditions, after linearizing the equation system, an asymptotic treatment of the problem can be given in terms WKB expansion of the fields. At the lowest order a non linear first order partial differential equation for the Phase Integral, formally equivalent to the Hamilton-Jacobi equation in classical mechanics, can be obtained and solved in terms of the ray trajectories, while at the next order a transport equation for the slowly varying wave energy density can be obtained and solved, thus allowing to reconstruct the electric field inside the plasma. Examples of solution for the propagation of the Lower Hybrid Waves, relevant in the heating and current drive of laboratory plasmas confined in toroidal devices (tokamak), will be shown and discussed.

Speaker: **CORRADO DE CONCINI, Dipartimento di Matematica, Sapienza Università di Roma**
Title: **The range of the index of an operator transversally elliptic with respect to a torus.**

Abstract: I will briefly describe which distributions on a compact Lie torus are obtained as index of a transversally elliptic operators in terms of their Fourier coefficients.
Joint work with C. Procesi and M. Vergne

Speaker: **SERGEY YU DOBROKHOTOV, Institute of Problems of Mechanics, Moscow (Russia)**
Title: **Localized asymptotic solutions in 2-D linear run-up problem with curvilinear boundary**

Abstract: We consider the 2-D wave equation with the smooth variable velocity c(x_1,x_2) in the domain D with the boundary \partial D in the situation when c(x_1,x_2)=0 on \partial D. We assume that near \partial D, c^2(x_1,x_2)\ sim \rho, where \rho is the distance between point (x_1,x_2) and the boundary \partial D. We consider the Cauchy problem in D with the initial data localized in the neighborhood of a certain point (x_1^0,x_2^0) \in D and appropriate boundary conditions on \partial D. Using the idea that the boundary \partial D could be viewed as the caustic of special type we construct the its asymptotic solutions with the help of the modified Maslov canonical operator which in the neighborhood of the boundary is realised in the for of the Hankel transform.
We discuss the application of obtained asymptotic formulas to so-called run-up problem in tsunami waves.
This work was done together with V.Nazaikinskii and B.Tirozzi

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Speaker: **JANFENG FENG, Centre for Scientific Computing, Warwick University (UK)**
Title: **Bridgind gaps between Multiscale Datasets in Mental Disorders**

Abstract: In the past few years, we have worked/collected large samples (around 1000 each) of a few mental disorders with whole genome, brain image and behaviour (symptoms) data. It gives us a unique and unprecedented opportunity to explore the aetiology of the disorders with data driven, modelling and experimental approaches. During the talk, a few example are presented to illustrate our approaches and in particular, we will discuss how to identify biomarkers at brain image level (PET, sMRI, fMRI, DTI) and explore the relationship between data with different scales, for example, SNPs, brain image and behaviours.

Speaker: **KRZYSZTOF GAWEDZKI, Départm. de Physique, Ecole Normale Supérieure, Lyon (FR)**
Title: **Topological invariants for periodically driven insulators**

Abstract: I shall discuss the generalization of invariants classifying topological insulators to the case of periodically driven systems.

Speaker: **FRANCESCO GUERRA, Dipartimento di Fisica, Sapienza Università di Roma (IT)**
Title: **Consequences of self-averaging in neural networks: the relevance of the Pastur-Scherbina-Tirozzi approach**

Abstract: Some years ago, in a remarkable paper, Pastur-Scherbina-Tirozzi proved that the hypothesis of self-averaging for the order parameters in neural networks leads necessarily to the expression for the free energy given by Amit-Gutfreund-Sompoliski. We will analyse the method exploited in this proof, point out possible extensions, and propose alternative methods based on the cavity approach.

Speaker: **ANTII KUPIANEN, Dept. of Math. & Stat., Confluence Helsinky University (FI)**
Title: **"Renormalizing Stochastic PDE's"**

Abstract: I discuss a renormalization group method to study PDE's driven by a noise which is white in space time. Examples are the KPZ equation and the ϕ_3^4 model.

Speaker: **SANDRO MAGRI', Freenet, Roma (IT)**
Title: **Early adoption of Unix, TCP/IP and the Internet in aid to research in mathematical physics**

Abstract: The pioneering use of computer tools such as Internet, Unix and open source software since the mid-eighties, in the group of mathematical physics of the Prof. Tirozzi, one of the first experiences in Italy, anticipated their widespread use in the next decade, ...

Speaker: **STEFANO MARIANI, Istituto Superiore Protezione e la Ricerca Ambientale, Roma (IT)**
Title: **Evaluating the performance of numerical weather prediction systems: Statistics and methods for forecast verification**

Abstract: The assessment of weather forecasts is one of the primary goals of any meteorological, hydrological and environmental institutions running numerical weather prediction (NWP) systems. This is consequence of the need for these institutions to constantly assess the skill and value of the forecasts provided by their systems. A statistical verification approach is then compulsory to provide for such NWP systems a robust and reliable assessment through time of the forecast performance. In addition, statistics

and methods for forecast verification can be used to evaluate the impact of any modifications introduced in a forecasting system.

The choice of the verification methodology used to verify a NWP system and to intercompare different NPW systems (or different model versions) is important. Usually, verification is based on performing exploratory data analysis and computing one or more performance statistics that evaluate the correspondence between forecasts and observations. However, in the last two decades, diagnostic feature-based verification methods have become more and more popular in the forecast verification community because they provide thorough information on forecast quality.

The talk provides some examples of the statistics and methods deployed for forecast verification for both scientific research and operational activities. In particular, attention is devoted to present results related to the performance of NWP systems in terms of quantitative precipitation forecasts (QPFs). Operational meteorological centres commonly consider the evaluation of QPF performance as a general indicator of the capability of a forecasting system to produce a good forecast.

Speaker: **GIOVANNI MONTANI, FUSMAG Laboratory, ENEA, Frascati (IT)**
Title: **Accretion Processes in Astrophysics: Cross-fertilization with Laboratory Plasmas?**

Abstract: We present the original idea of Shakura on the accretion mechanism onto compact astrophysical objects, outlining the successes and the shortcomings of the so-called Standard Model for accretion. Then, we propose a possible reformulation of the accretion processes, within a gravitating plasma disk, in term of an ideal MHD approach to the equilibrium configuration and to the linear stability problem. We show how this alternative scenario predicts the emergence of magnetic micro-structures across the plasma disk, able to fragment it into a ring series, as soon as strongly non-linear regimes are analyzed. The new proposal for the morphology of the accreting astrophysical structures is closely related to well-established properties of laboratory plasmas, like those ones confined in Tokamak devices and we discuss up to which extent such an analogy can be carried on.

Speaker: **VLADIMIR E. NAZAIKINSKII, Institute of Problems of Mechanics, Moscow (Russia)**
Title: **Asymptotic solution of the wave equation with rapidly oscillating coefficients.**

Abstract: We consider the wave equation with rapidly oscillating velocity c(x). Under the assumption that c(x) satisfies certain homogenizability conditions, we construct asymptotic solutions of this equation that oscillate rapidly but slower than c(x). (Physically, this means that a typical wavelength is much larger than the spatial scale of velocity oscillations.) The construction is based on the approach to the adiabatic approximation developed in [1--3]. Relations with the classical homogenization methods ([4--7] etc.) are discussed.
The talk is based on a joint research with S. Yu. Dobrokhotov and B. Tirozzi.

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Speaker: **ENZO OLIVIERI, Dipartimento di Matematica, Università di Roma "Tor Vergata" (IT)**
Title: **Lattice spin-systems outside criticality via scale adapted cluster expansion.**

Abstract: Various lattice models are analysed especially in the field of disordered systems. A relatively simple case is given by one-dimensional state space with two-body random interaction with suitable

inverse power (one-dimensional spin glass). For suitable values of the parameters the system can undergo a Griffith phase transition. (Thermodynamic functions are C_infinity but not analytic).

Speaker: **MARCO PIERSANTI, Asco Power AG, Baden (SW)**
Title: **Wind into Power - Forecasting wind power production using ANNs**

Abstract: Forecasts of wind power are paramount for various management tasks, such as quantification of reserves, economic dispatch of wind generation within a broader portfolio or design of optimal trading strategies. Compared with physical methods (based on CFD), statistical methods are usually simpler and more suitable for small wind farms. Based on the conjunction of Numerical Weather Predictions (NWPs) and Artificial Neural Networks (ANNs), a new short-term forecasting method is proposed. Simulation upon actual time data shows that all the usual error measures for the multi-step forecasting based on the proposed method are smaller, if compared with simpler models or with commercial benchmarks available on the market.

Speaker: **STEFANO PITTALIS, Istituto di Nanoscienze, C.N.R., Modena (IT)**
Title: **Ab-initio description of charge separation for solar energy conversion on the nano scale**

Abstract: I will illustrate how the quantum-mechanical many-body problem at the basis of solar energy conversion realized in large molecular systems can be studied in an ab-initio fashion by means of time-dependent density functional theory.
As an application, I will consider a novel compound -- a diaminoterephthalate-C60 diad – which is predicted to function similarly to nano-solar cell.

Speaker: **ERRICO PRESUTTI, Dipartim. di Matematica, Università di Roma "Tor Vergata" (IT)**
Title: **Hydrodynamic limit for interacting neurons**

Abstract: My talk is about a recent paper I wrote in collaboration with Anna De Masi, Eva Loecherbach and Antonio Galves where we have studied the hydrodynamic limit of a stochastic process describing the time evolution of a system with N neurons with mean-field interactions produced both by chemical and by electrical synapses.
This system can be informally described as follows. Each neuron spikes randomly following a point process with rate depending on its membrane potential.
At its spiking time, the membrane potential of the spiking neuron is reset to the value 0 and, simultaneously, the membrane potentials of the other neurons are increased by an amount of *energy* 1/N. This mimics the effect of chemical synapses. Additionally, the effect of electrical synapses is represented by a deterministic drift of all the membrane potentials towards the average value of the system. We show that, as the system size N diverges, the distribution of membrane potentials becomes deterministic and is described by a limit density which obeys a non linear PDE which is a conservation law of hyperbolic type.

Speaker: **LUIGI PREZIOSI, Department of Mathematical Sciences, Politecnico di Torino (IT)**
Title: **Modelling the formation of capillary networks**

Abstract: Two major mechanisms are involved in the formation of blood vasculature:
vasculogenesis and angiogenesis. The former term describes the formation of a capillary-like network from either a dispersed or a monolayered population of endothelial cells, reproducible also *in vitro* by specific experimental assays. The latter term describes the sprouting of new vessels from an existing capillary or post-capillary venule.

Similar mechanisms are also involved in the formation of the lymphatic system through a process generally called lymphangiogenesis. A number of mathematical approaches have been used to analyse these phenomena.
In this article, we review the different types of models, with special emphasis on their ability to reproduce different biological systems and to predict measurable quantities which describe the overall processes. Finally, we highlight the advantages specific to each of the different modelling approaches.

Speaker: **CLAUDIO PROCESI, Dipartimento di Matematica, Sapienza Università di Roma (IT)**
Title: **Quasi-periodic orbits and non-linear differential equations**

Abstract: The notion of quasi-periodic orbit is one of the fundamental ideas in the Theory of dynamical systems, since it corresponds to physical systems which move under independent periodic motions of distinct coordinates. A major discovery was in 50's KAM theory which gives some mathematical explanation of the persistence of quasi-periodic motions under small perturbations, as for instance, after many more years of research, in celestial mechanics and in the description of the solar system. The theory has been extended also to non-linear partial differential equations. In particular I will show how the study of quasi -periodic solutions of the non-linear Schrodinger equation in dimension >1 is connected to the rich combinatorics of an interesting infinite graph built from rectangles.

Speaker: **MARIO PULVIRENTI, Dipartimento di Matematica, Sapienza Università di Roma (IT)**
Title: **Rigorous derivation of the Fick's law in a low-density regime**

Abstract:

Speaker: **LAVINIA RONCORONI, Max Planck Institute for Mathematical Sciences, Leipzig, (GE)**
Title: **Lumpability of Abstract Cauchy Problems**

Abstract: We analyze lumpability of evolution equations, namely, the possibility of projecting a dynamics by a linear reduction operator onto a smaller state space on which a self-contained dynamical description exists. We deal with linear Abstract Cauchy problems on infinite dimensional Banach spaces, using methods from the theory of strongly continuous semigroups. Next, we introduce the lumpability problem for nonlinear systems, discussing some possible connections with the center manifold theory.

Speaker: **GIULIA ROTUNDO, Memotef, Sapienza Università di Roma (IT)**
Title: **Risk and return of mutual funds and stocks. A network analysis on funds holdings.**

Abstract: The increasing interconnection of markets, their sensitivity to contagions and the recent overall fragility of the financial system raise some questions on risk due to the overlap and interlacement of investments.
The present research aims to explore the relationship among the equity exposure and both performance and risk of mutual funds investing in stocks of European companies. At the same time, the analysis represents an attempt to shed light on the relationship between stocks position within the network and their future market performance and risks.
We start analyzing whether there is any evidence that funds managers take common decision on trading, both for benchmark constraints and for style management purposes. We explore the network structure of both stocks and funds through the construction of a bipartite network and the projection of the available information on both the space of mutual funds and stocks traded in the stock exchange. Methods typical of complex networks are then applied. Cluster analysis also evidences club effects and the most relevant stocks on markets.
The results of the research become the grist for new insights in the picture of portfolio management techniques and on the role of benchmarks in the mutual fund world.

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Speaker: **MARIYA SHCHERBINA, Institute of Low Temperatures, Khrakov (Russia)**
Title: **Central limit theorem in the problems of the spin glass theory and the random matrix theory.**

Abstract: The central limit theorem (CLT) for the fluctuations of the free energy of mean field models of spin glasses and the linear eigenvalue statistics of different ensembles of random matrices will be discussed. The recent results on the CLT for the fluctuation of the eigenvalue number for real symmetric and symplectic matrix models will be presented.

Speaker: **ANTONIO SPERANZA, C.I.N.F.A.I. & Dipart. Di Matem. & Inform. Camerino Univ. (IT)**
Title: **Self-Nonlinearity and statistical intermittence of atmospheric planetary fluctuations.**

Abstract: The general circulation of the atmosphere is strongly influenced by planetary-scale fluctuations with zonal wavenumber in the range $k = 1 \div 4$. The statistics of their amplitudes stands out as being markedly non-gaussian, in direct contrast with the unimodal distribution of amplitudes in the baroclinic range ($k \geq 5$). Moreover, the space-time spectral variance in the baroclinic range displays signature of a dispersion relation (although modified by unstable growth and/or nonlinearity), while in the ultra-long range ($k = 1 \div 4$, T> 10 days) no univocal frequency-wavenumber relationship can be read: standing modulations (mainly due to mountains, since the observed vertical structure is columnar) together with nonlinearity are assumed to play an essential role in determining the observed properties. Nonlinear self-interaction (or, in short, self-nonlinearity) of Rossby waves is determined by meridional advection of vorticity and increases with the structural complexity of fluctuations, both dependent on their zonal wavenumber k and meridional profile.
By means of perturbation expansion of the barotropic vorticity equation we draw a theoretical description of this phenomenon and we show that nonlinear self-interaction is responsible for a correction term to phase speed, with the prevalent effect of slowing down the propagation of waves and the consequent modification of the linear dispersion relationship.
The intensity of nonlinear self-interaction is shown to increase with the structural complexity of

fluctuations, both dependent on *k* and their meridional profile. Working on reanalysis geopotential data, it is suggested that this process can contribute to the development of blocking episodes, *i.e.* anticyclonic structures characterised by very limited mobility which critically affect weather and climate.

Speaker: **GABRIELE STABILE, Facoltà di Economia, Sapienza Università di Roma (IT)**
Title: **Individual investment decisions for retirement savings: a stochastic control approach**

Abstract: In this paper we study the personal investment decisions for retirement. We consider an individual who may voluntary contribute to a retirement saving fund or may invest in a financial market. The contribution to the retirement fund is costless, whereas withdrawals are charged by costs. The financial market is assumed to be frictionless. The retirement plan guarantees greater expected return and lower volatility in respect to those characterizing the financial market. At retirement, the retirement fund is converted into a lifelong riskless annuity. The individual aims at maximizing the utility deriving from consumption ow over all portfolio and contribution policies.
From a mathematical point of view the problem is formalized as a regular/singular stochastic control problem. The model takes into account the financial risk as well as the demographic aspects. The markovian structure allows us to study the problem using the dynamic programming approach.

Speaker: ANGELO TUCCILLO, Fusion, ENEA, Frascati (IT)
Title: **Magnetic Confined Fusion: Status and Perspectives**

Abstract: Since its declassification in 1958, the research on pacific utilisation of nuclear fusion has strongly progressed toward the realisation of a power plant with both approaches: magnetic confinement and inertial. Nevertheless, many problems still remain open before a DEMOnstrative reactor will be realised. Here we will briefly summarise the progress of the fusion research with the magnetic confinement approach. We will highlight the results achieved by the devices of the present generation, in particular by the most promising magnetic configuration, the so called “tokamak”. The remaining open issues will be addressed with indications of how they will be tackled by next generation machines. The world wide project, ITER, in construction in the south of France, will be described. Finally the Italian proposal of a new tokamak able of addressing, at reduced cost, the relevant open issues in view of ITER and DEMO will be presented and the possibility of its integration in the EU programme, Horizon-2020, will be discussed.

Organizers:
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