SAPIENZA
UNIVERSITÀ DI ROMA

Dipartimento di Fisica, Sapienza Universita' di Roma

Five decades of Theoretical Physics: Looking forward looking backward

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Sergio Alberverio

Infinite dimensional integrals and applications.

Abstract:

Pierluigi Contucci

Stochastic Stability and the Ghirlanda-Guerra identities. Results and perspectives.

Abstract:

Some invariances under perturbations of the spin glass phase will be introduced, their proofs outlined and their consequences illustrated as factorization rules for the overlap distribution. Perspectives on the comparison between mean field and short range models will be discussed.

Roberto Dautilia

Power laws and sustainability for the coexistence of the urban and rural environment.

Abstract:

Since few years, more than half of the world's population is living in the city.
For its need of energy and water, waste production and demand for food, the city of the next years will be a complex network affecting seriously the life of the surrounding environment.
A power law relating the pace of the city to its size has been recently suggested, at least for some quantities driving its demographic growth.
For some of these quantities, the power law exponent turns out to be greater than one, giving rise to a superlinear population growth.
Taking into account the whole urban-rural system we consider a similar power law dependence for the "land use" resource.
Due to the finite agricultural resource, we found that the corresponding population dynamics equation is a Chini like ordinary differential equation with non integer exponent for the nonlinear term.
For the simplest case where the agricultural resource decreases only for anthropic pressure, the solution shows that even for the exponent beta <1, the initial conditions can make unsustainable the urban growth.
If we constrain the food traveling costs, the carrying capacity of the country surrounding the city can be evaluated.
This result suggest an urgent need to identify strategies for urban development which preserve the agricultural lands.
The model has been applied to the case of land use in Lombardy (Italy) where suitable data are available.

Silvio De Siena

Collective dynamics and aggregation mode of "many-particle" (classical) systems by stochastic methods.

Abstract:

In the talk it is presented a phenomenological approach to describe, and possibly to control, the collective dynamics of regime. The underlying idea is that the collective motion and the evolution of the density of these systems are described in an effective way by a representative particle whose dynamics can be derived from the stochastic variational principles of Nelson-Guerra-Morato. The approach is exploited to investigate, in particular, the dynamics of bunches of particles in accelerators. Furthermore, in the final part of the talk will be quickly presented a coarse method to account for the aggregation mode of systems of the same nature which are disposed on a sequence of scales, with specific reference to astrophysical systems.

Carlo Di Castro

Heterogeneous states in the physics of the High Temperature Cuprates Superconductors.

Abstract:

The understanding of the anomalous metallic state out of which high temperature superconductivity develops, is a fascinating topic, preliminary to the individuation of the superconductivity mechanism itself.

New x-ray scattering [1] experiments identify a two-dimensional charge density wave as the order competing with superconductivity in the CuO_2 planes of a typical high-*T*c superconductor (YBCO). These experiments, together with our recent theoretical interpretation of Raman and ARPES experiments [2], rprovide a new and direct evidence in support of the proposal developed along the years by our group in Rome [3] of the anomalous metallic behaviour as due to the formation of an heterogeneous state. This state arises from a Fermi Liquid instability as an incommensurate charge density wave modulation which evolves by underdoping into various clustering of different morphologies (stripes, droplets, checkerboard,…) [4], according to experimental findings.

The onset of the heterogeneous state is governed by a critical line ending into a (hidden) quantum critical point around optimal doping (doping with maximum critical superconductivity temperature). The quasi-critical modes [2], resulting from this charge (and spin) competing order, act as mediators of the effective electron-electron interaction.

In the very low doping regime, where no charge order has been observed, we have recently proposed a new phase [5]. Starting from the undoped aniferromagnetic side of the phase diagram, the doped holes organize themselves into equally oriented dipolar chain segments, which have a spin vortex and a spin antivortex at the extremes. The resulting ferronematic state can be characterized as a charge nematic state that, due to the net polarization, breaks inversion symmetry and also exhibits the incommensurate spin modulation observed by neutron scattering.

References:

[1] G. Ghiringhelli et al. Long-range incommensurate charge fluctuations in (Y,Nd)$Ba_2Cu_3O_{6+x}$ Science 2012. J. Chang et al. Direct observation of competition between superconductivity and charge density wave order in YBa2Cu3Oy.

[2] S. Caprara, C. Di Castro, B. Muschler, W. Prestel, R. Hackl, M. Lambacher, A. Erb, S. Komiya, Y. Ando, and M. Grilli, Phys. Rev. B 84, 054508 (2011). G. Mazza, M. Grilli, C. Di Castro, and S. Caprara. Kinks and waterfalls as signatures of competing order and quantum criticality in $La_{2-x}Sr_xCuO_4$ angle-resolved photoemission spectra. Submitted for publication.

[3] C. Castellani et al. PRL 95, 4650 (1995). Z. Phys. B 103, 137 (1997). J. of Phys. and Chem. of Sol. 59, 1694-1698 (1998). Perali et al. PRB 54,16216 (1996). Andergassen et al. PRL 87, 056401 (2001).

[4] C. Ortix, J. Lorenzana and C. Di Castro, PRL 100, 246402 (2008).

[5] G. Seibold, M. Capati, C. Di Castro, M. Grilli and J. Lorenzana. Hidden Ferronematic order in underdoped cuprates. (arXiv:12042119)

Sergio Doplicher

The Principle of Locality and the Measurement Process in Quantum Field Theory

Abstract:

We describe in a qualitative way a possible picture of the Measurement Process in Quantum Mechanics, which takes into account:

1. the finite and non zero time duration T of the interaction between the observed system and the microscopic part of the measurement apparatus;
2. the finite space size R of that apparatus;
3. the fact that the macroscopic part of the measurement apparatus, having the role of amplifying the effect of that interaction to a macroscopic scale, is composed by a very large but finite number N of particles.

We argue that this picture should apply to the given, unique time evolution expressing the dynamics of a given theory, and should comply with the Principle of Locality. The proposed scheme is merely sketched, and ought to be made mathematically precise, to be testable in specific models. We comment on the Einstein Podolski Rosen thought experiment, reformulated here only in terms of local observables (rather than global ones, as one particle or polarisation observables). The local picture of the measurement process helps to make it clear that there is no conflict with the Principle of Locality.

Silvio Franz

Response Functions in Spin Glasses

Abstract:

The ideas of Francesco Guerra have been shaping the mathematical physics of spin glasses.
I will review two topics where the influence of Francesco has had a strong impact in my research
1) The implications of Stochastic Stability for Long Time Glassy Dynamics.
2) The Interpolation Method for Diluted Spin Glass Systems and Random Constraint Satisfaction Problems.

Sandro Graffi

Quantum normal forms and exact quantization formulae

Abstract:

The method of the quantum normal form for approximating the eigenvalues of Schroedinger operators is briefly reviewed. A suitable class of operators is isolated for which the quantum normal form can be proved to converge uniformly with respect to the Planck constant. This yields an exact quantization formula for the quantum spectrum as well as a new example of convergence for the classical normal form.

Fabrizio Illuminati

Factorization, frustration and entanglement in complex quantum systems

Abstract:

I will report on some recent and ongoing progress in the application of tools of entanglement theory to the study of complex quantum many-body systems. I will first review the general theory of ground-state factorization points [1]. Next, I will consider the interplay between classical and quantum frustration, and I will discuss universal lower bounds relating frustration to ground-state entanglement [2] and factorization [3]. Finally, I will discuss the role played by frustration and factorization concerning the behaviour of the Rényi entanglement entropies in quantum many-body systems. In particular, I will show how the violation of the area-law scaling implies the existence of entanglement-driven quantum phase transitions that are independent of symmetry breaking and cannot be detected by local order parameters [4]. A hierarchy of non-local entanglement order parameters will be identified, and their possible application to systems with spin-liquid ground states and global topological order will be briefly outlined.

References:
[1] S. M. Giampaolo, G. Adesso, F. Illuminati, Phys. Rev. Lett. 100, 197201 (2008); Phys. Rev. B 79, 224434 (2009).
[2] S. M. Giampaolo, G. Gualdi, A. Monras, and F. Illuminati, Phys. Rev. Lett. 107, 260602 (2011).
[3] S. M. Giampaolo, G. Adesso, and F. Illuminati, Phys. Rev. Lett. 104, 207202 (2010).
[4] S. M. Giampaolo, S. Montangero, F. Dell'Anno, S. De Siena, and F. Illuminati, arXiv:1208.0735 (2012).

Gianni Jona-Lasinio

Looking backward: Reminiscences of Stochastic Mechanics

Abstract:

I had the fortune of attending a small meeting in 1965 at MIT where Ed Nelson presented - I believe for the first time - stochastic mechanics, a subject which later I learnt in more detail in lectures by Francesco. I was intrigued and used it. I will briefly discuss a relationship not so well known between the stochastic mechanics of a non relativistic spin in a magnetic field and Cartan's theory of spinors.

Joel Lebowitz

Realizability and extension of measures: Classical and Quantum

Abstract:

I will describe some work trying to answer the following type of questions:
(a) When do the real numbers M1,M2,....Mk correspond to the first k-moments of a probability distribution on the non-negative integers?
(b) When does an approximate radial distribution function for a fluid come from some distribution?
(c) When is a given measure on a point process in a domain A contained in Z^d or R^d the projection of a translation invariant measure on Z^d or R^d?
(d) When are density matrices r(1,2) and r(2,3) which agree on 2 the traces of a density matrix r(1,2,3)?

Enzo Marinari

A statistical mechanical analysis of genome scale metabolic networks.

Abstract:

The integration of various types of genomic data into predictive models of biological networks is one of the main challenges currently faced by computational biology. Constraint-based models in particular play a key role in the attempt to obtain a quantitative understanding of cellular metabolism at genome scale. In essence, their goal is to frame the metabolic capabilities of an organism based on minimal assumptions that describe the steady states of the underlying reaction network via suitable stoichiometric constraints, specifically *mass balance* and *energy balance* (i.e. thermodynamic feasibility). The implementation of these requirements to generate viable configurations of reaction fluxes and/or to test given flux profiles for thermodynamic feasibility can however prove to be computationally intensive. We propose here a fast and scala ble stoichiometry-based method to explore the Gibbs energy landscape of a biochemical network at steady state. The method is applied to the problem of reconstructing the Gibbs energy landscape underlying metabolic activity in the human red blood cell, and to that of identifying and removing thermodynamically infeasible reaction cycles in the *Escherichia coli* metabolic network (iAF1260). In the former case, we produce consistent predictions for chemical potentials (or log-concentrations) of intracellular metabolites; in the latter, we identify a restricted set of loops (23 in total) in the periplasmic and cytoplasmic core as the origin of thermodynamic infeasibility in a large sample 10^6 of flux configurations generated randomly and compatibly with the prior information availableon reaction reversibility.

Marc Mezard

Spin glasses and crystal nucleation in massive data acquisition

Abstract:

The new field of compressed sensing is triggering a major evolution in signal acquisition. It consists in sampling a sparse signal at low rate and later using computational power for its exact reconstruction, so that only the necessary information is measured. Currently used reconstruction techniques are, however, limited to acquisition rates larger than the true density of the signal. We shall describe a new procedure, based on a detailed statistical physics analysis, which is able to reconstruct exactly the signal with a number of measurements that approaches the theoretical limit in the limit of large systems.

References:
[1] F. Krzakala, M. Mezard, F. Sausset, Y. Sun and L. Zdeborova, Phys. Rev. X 2 (2012) 021005 ; J. Stat. Mech. (2012) P08009

Edward Nelson

A problem in computational complexity.

Abstract:

A new approach to the P versus NP problem will be presented.

Dmitry Panchenko 40’

The Sherrington-Kirkpatrick model: an overview.

Abstract:

The goal of this talk is to review some of the main ideas that emerged from the attempts to confirm mathematically the predictions of the celebrated Parisi ansatz in the Sherrington-Kirkpatrick model.

Giorgio Parisi

Recent results on very large scale spin glass simulations.

Abstract:

David Sherrington

Spin glasses; looking backward, forward and sideways.

Abstract:

Solving the statistical mechanics of the mean-field spin glass problem with mathematical rigour has been a topic to which Francesco Guerra has contributed greatly, following the remarkable insights and methodologies developed by his theoretical physics colleague Giorgio Parisi, both ably complemented by many other members of the Roman team, including its diaspora.

I shall describe briefly some of the physics history that led to the canonical model, some of the transfers of the knowledge gained, both conceptual and technical, to other many-body systems of simple microscopic entities but made complex at the macroscopic level by frustration and quenched disorder, and mention some possible interesting problems for the future.

I shall concentrate on ideas and physical reasoning. I shall not concern myself with mathematical rigour, rather leaving that to others who are more able in that métier, such as Francesco and his associates.

Salvatore De Martino 20'

Self-sustained oscillations in natural systems

Abstract:

We review a variety of analysis and phenomenological models for natural systems displaying self-sustained oscillations.