Non perturbative solutions in field theory and their applications

10 June 2019 - Aula Anni, Dept. Physics "E. De Giorgi", Lecce, Italy

The meeting focuses on recent nonperturbative results in Field Theory and their potential applications to a broad range of phenomena, including nuclear physics, classical and quantum fluid dynamics.

The idea is to bring together people with different background but using similar tools in theoretical physics, both in terms of analytical and computational approaches.

Talks will cover topics such as topological structures in nuclear and condensed matter, turbulent regimes in Bose-Einstein condensates, space-time singularities and their regularization in classical and quantum fluids.

List of Speakers

Stefano Bolognesi (University of Pisa and INFN)

Boris Konopelchenko (University of Lecce and INFN)

Luigi Martina (University of Lecce and INFN)

Guido Macorini (CNR NANOTEC and INFN)

Carlos Naya (University of Lecce and INFN)

Miguel Onorato (University of Torino and INFN)

Davide Proment (University of East Anglia, Norwich, UK)

Organization:

Luigi Martina (Unisalento and INFN) and Alessandra S. Lanotte (CNR NANOTEC and INFN)

Dipartimento di Matematica e Fisica "Ennio De Giorgi"

CNRNANOTEC INSTITUTE OF NANOTECHNOLOGY

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PROGRAM	June 10, 2019 - AULA ANNI, Dip. Di Matematica e Fisica E. De Giorgi
10:50	**Opening of the Workshop with Coffee**
11:10 11:45	**Boris Konopelchenko** *Universal parabolic regularization of the gradient catastrophes for the Burgers-Hopf equation and Jordan chain*
11:50 12:25	**Stefano Bolognesi** *Near-BPS Solitons*
12:30 13:05	**Luigi Martina** *Skyrmions and Helicons in Chiral Liquid Cristals*
13:10 15:00	**Lunch break**
15:00 15:35	**Miguel Onorato** *Rogue Waves*
15:40 16:15	**Davide Proment** *Quantum turbulence cascades in the Gross–Pitaevskii model*
16:15 16:30	**Coffee break**
16:30 17:05	**Carlos Naya** *Skyrmions and Neutron stars*
17:10 17:35	**Guido Macorini** *The Gross-Pitaevskii equation for excition-polariton condensates*
17:45 18:00	**Conclusions**

Abstracts

Universal parabolic regularization of the gradient catastrophes for the Burgers-Hopf equation and Jordan chain
B. Konopelchenko

Non-standard parabolic regularization of gradient catastrophes for the Burgers- Hopf equation and integrable hydrodynamic type systems with the most degenerate Jordan blocks is considered. An approach is based on the analysis of the generic and all higher order gradient catastrophes and their step by step regularization by embedding the Burgers-Hopf equation and Jordan systems into integrable multi-component parabolic systems of quasi-linear PDEs with the most degenerate Jordan blocks.
Probabilistic realization of such procedure is discussed. The complete regularization is achieved by embedding into infinite Jordan chain. It is shown that the Burgers eq., Korteweg-de Vries eq. and other nonlinear PDEs are particular reductions of the Jordan chain.

Skyrmions and Helicoids in Chiral Liquid Crystals
Luigi Martina

Frustrated Chiral Liquid Crystals are described in terms of quasi-integrable nonlinear equations with boundary conditions. This aspect turns out to be essential in determining the admissible classes of solutions, which can be isolated (baby) - skyrmions and their lattices, or elongated helicoidal structures, possibly periodically assembled. Analytical and numerical studies are reported.

Skyrmions and Neutron Stars
Carlos Naya

The Skyrme model is a low energy effective field theory of strong interactions where nuclei and baryons appear as collective excitations of pionic degrees of freedom (topological solitons). Proposed by Tony Skyrme in the sixties, his ideas received further support when it was discovered that in the limit of the large number of colours of QCD, an effective theory of mesons arises. In the last years, there has been a revival of Skyrme's ideas and new related models, some of them with BPS bounds (topological lower energy bounds), have been proposed. It is the aim of this talk to study the application to neutron stars where we will find that high maximal masses are supported within a BPS version of the theory. In addition, the BPS Skyrme model allow us to perform both mean-field and exact calculations and a comparison between both approaches will be presented.

Quantum turbulence cascades in the Gross–Pitaevskii model
Davide Proment

I will present an overview of quantum turbulence regimes arising within in the Gross–Pitaevskii equation modelling Bose—Einstein condensates.
I will focus mainly on the direct energy cascade emerging in open (forced-dissipated) systems and explain it theoretically using the wave turbulence theory. I will show that the behaviour of the system is very sensitive to the spatial dimensionality, and forcing and dissipative scales.

Near-BPS Solition
Stefano Bolognesi

We consider solitonic models which admit small perturbations of BPS systems. These models are useful in order to achieve small binding energies. Both (baby-)Skyrmion and holographic QCD provide examples of this mechanism. In particular for the case of the baby-Skyrmion we can study for the first time the perturbation close to restricted baby-Skyrme model, which is a BPS model with area preserving diffeomorphism invariance.

The Gross-Pitaevskii equation for excition-polariton condensates
Guido Macorini

In this talk we briefly review some of the theoretical aspects (and open challenges) of modeling the exciton - polariton superfluid system by using the Gross Pitaevskii equation.

Rogue waves
Miguel Onorato

Surface gravity waves are fascinating perturbations of the interface between the atmosphere and the ocean: their oscillating properties are a direct consequence of gravity which acts as the restoring force. Apart from tsunamis whose origin is a fast displacement of a large volume of water, ocean waves are generated by winds that slowly, but inexorably, transfer them energy. Randomness is a peculiarity of ocean wind waves: wind forcing is in general turbulent, moreover, surface gravity waves are dispersive, which inevitably imposes a finite life time of any localised coherent wave-packet. If a time series of the surface elevation is recorded, its Fourier spectrum will be characterized by some width which is inversely proportional to the dispersion time scale and by some independent Fourier phases. Those are the prerequisites for a Gaussian probability density function of the surface elevation which indeed, with small deviations, is the one that mostly characterises ocean waves. Rarely, in conditions that still need to be understood, extreme waves, known as “rogue waves”, may appear on the surface of the ocean. Those waves can be very large (the most famous recording, known as the Draupner wave, shows a height of 25 meters) and can be extremely dangerous for ships or fixed offshore structures such as platforms. While this phenomenon is now well documented in the oceanographic literature, its origin is still very much debated either a rogue wave is a rare event belonging to a quasi-Gaussian distribution or it is a more frequent (in some sea states) event belonging to a different population. Despite the fact that the subject has been investigated for many years, the role of nonlinearity has not been fully addressed yet and many questions are still open.
After a short introduction to surface gravity waves, I intend to present a general overview of the state of the art of the field of rogue waves both from an experimental and theoretical point of view. New developments and future prospective will also be discussed.