Nice Nonlinearities Conference

14-15 December 2017
Hotel Le Saint-Paul, 29 Boulevard Franck Pilatte
Nice

A conference in honour of Pierre Coullet

https://nonlinearities.sciencesconf.org/

UCA JEDI
INITIATIVE D'EXCELLENCE

INPHYNI
INSTITUT DE PHYSIQUE DE NICE

DOEBLIN

PROGRAMME

Thursday 14 December 2017

9h30 : ***Welcome***

10h00 : *Directeur INPHYNI : Guillaume Huyet.*

10h20 : *A.Newell: Pattern Universes*

10h40 : *S. Fauve : Random reversals of a vector field on a turbulent background*

11h00 : *Pause*

11h20 : *M. G. Velarde: Supersonic soliton electron surfing along an-harmonic molecular wires: truth and consequences*

11h40 : *G. Iooss:Bifurcating quasipatterns in Bénard-Rayleigh convection*

12h00 : *E. Guyon: Robert Hooke au lycée des Eucalyptus*

12h30 : *Lunch at « Le Saint Paul »*

14h00 : *D. Clamond: Computation of highly nonlinear steady surface gravity waves in arbitrary depth*

14h20 : *A. Pumir: Extremely large velocity gradients in turbulent flows*

14h40 : *Président UCA: J.-M. Gambaudo*

15h00 : *M. Bellec: Experimental evidences of light superfluidity in a bulk nonlinear crystal*

15h20 : *Pause*

16h00 : *P. Clavin: Critical conditions of direct initiation of detonation*

16h20 : *A.Seminara: Olfactory Navigation*

16h40 : *C. Raufaste: Flow and nonlinearities inside the liquid foam microchannels*

17h00 : *D. Vincenzi: Is elasticity necessary for elastic turbulence?*

17h20: *S. Nazarenko Gravitational Waves and Turbulence in the Early Universe*

17h40: *P. Coullet: Image inversion and Fermat's principle*

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Friday 15 December 2017

9h00 : *Y. Couder: A case of information interplay between a particle and a wave.*

9h20 : *S. Rica : Anatomy of vortex reconnection*

9h40 : *K. Emilsson : Human patterns*

10h00 : *E. Villermaux: In P. Coullet's (early) style: A deterministic dynamics leading to broad statistics; Node dynamics at the border of liquid sheets.*

10h20 *: T. Passot: Fluid approaches for sub-ionic turbulence in space plasmas*

10h40 : *Pause*

11h00 : *J. Tredicce: Extreme events and their indicators in nonlinear dynamics*

11h20 : *M. Brachet: Statistical theory of reversals in two-dimensional confined turbulent flows*

11h40 : *G. Huyet : Lasers for optical imaging*

12h00 : *P. Chossat: Heteroclinic chains as a model of sequential activation of concepts in neural networks*

12h30 : *Lunch at le Saint-Paul*

14H00 : *N. Vandenberghe: The fragmentation of a cohesive ring*

14h20 : *C. Josserand: Pattern formation in freezing droplets*

14h40 : *S. Barland: Interacting spikes of light in a delayed system*

15h00 : *M. Argentina: Scaling laws for a compliant biomimetic swimmer*

15h20 : *G. Sonnino: Transport Closure Equations for Studying Tokamak-plasmas in Turbulent Regime*

15h40 : *Pause*

16h00 : *T. Frisch: Elastic instabilities in semiconductor films.*

16h20 : *E. Risler : Kindergarten mathematics*

16h40 : *M. Giudici: Temporal Localized Structures in Passive Mode-Locked Semiconductor Lasers*

17h00 : *P. Genevet: Planar optics with metasurfaces*

17h20 : *Y. Pomeau: Regarder autour de nous et tenter de comprendre. En hommage à l'ami Pierre Coullet*

18h00 : ***Final Discussion***

Organizing committee

Médéric Argentina, Thomas Frisch, Guillaume Huyet, Magali Dusaucy

Contact person: ***Magali.dusaucy@inphyni.cnrs.fr***

Sponsors

Title: Scaling laws for a compliant biomimetic swimmer

Authors: F. Gibouin, C. Raufaste, Y. Bouret, M. Argentina

Affiliation: Institut de Physique de Nice, Université Côte d'Azur

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Short Abstract

Motivated by the seminal work of Lord Lighthill in the sixties, we study the motion of inertial aquatic swimmers that propels with undulatory gaits. We have uncovered the law linking the swimming velocity to the kinematics of the swimmer and the fluid properties (Nat. Phys. 2014). At high Reynolds numbers, the velocity appears to be equal to $0.4Af/(2\pi)$, where A and f are respectively the amplitude and the frequency of the oscillating fin. We have constructed a compliant biomimetic swimmer, whose muscles have been modeled through a torque distribution thanks to a servomotor. A soft polymeric material mimics the flesh and provides the flexibility. By immersing our robot into a water tunnel, we find and characterize the operating point for which the propulsive force balances the drag. We bring the first experimental proof of the former law and probe large amplitude undulations which exhibits nonlinear effects. All data collapse perfectly onto a single master curve. We investigate the role of the fin flexibility by varying its length and its thickness and we figured out the existence of an efficient swimming regime.

Title: Interacting spikes of light in a delayed system

Authors: Bruno Garbin, Julien Javaloyes, Giovanna Tissoni, Stéphane Barland

Affiliation: Institut de Physique de Nice, Université Côte d'Azur

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Short Abstract

Many years ago, Coullet and coworkers suggested that a laser submitted to external forcing could mimic the dynamical behavior of a neuron. We couple such a neuron to itself via a delay term and show experimentally and theoretically the emergence of localized states analogues in this delayed system. We discuss the impact of (nonreciprocal) interactions between these localized states on the global dynamics.

Title: Experimental evidences of light superfluidity in a bulk nonlinear crystal

Authors: Omar Boughdad, Mathias Albert, Claire Michel and Matthieu Bellec

Affiliation: Institut de Physique de Nice, Université Côte d'Azur & CNRS

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Short Abstract

We will discuss the recent direct experimental detection of the frictional-superfluid transition in the flow of a fluid of light past a weakly perturbing localized obstacle in a bulk nonlinear crystal.

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Title: Statistical theory of reversals in two-dimensional confined turbulent flows

Authors: Vishwanath Shukla, Stephan Fauve, Marc Brachet

Affiliation: Laboratoire de Physique Statistique, École Normale Supérieure, PSL Research University; UPMC Univ Paris 06, Sorbonne Universités; Université Paris Diderot, Sorbonne Paris-Cite´; and CNRS, 24 Rue Lhomond, 75005 Paris, France.

e-mail of the speaker: marc.brachet@gmail.com

Short Abstract

The truncated Euler equation is a finite set of ordinary differential equations for the amplitude of the large-scale modes. It is shown to correctly describe the transitional dynamics in the turbulent regime of a confined 2D Navier-Stokes flow with bottom friction and periodic forcing. A minimal 13-mode model is presented.

Title: Heteroclinic chains as a model of sequential activation of concepts in neural networks

Authors: C.Aguilar, P. Chossat, M. Krupa, F. Lavigne

Affiliation: Laboratoire JA Dieudonné, UCA CNRS.

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Short Abstract:
We apply the notions of heteroclinic chains and slow-fast systems to analyze dynamical phenomena occuring in neural networks with synaptic depression, which model sequential associations of previously learned ideas and concepts in the brain. This "latching" dynamics holds in a small domain in parameter space, indicating that more accurate learning rules and networks should be invoked to explain this very basic property of associative memory.

Title: Computation of highly nonlinear steady surface gravity waves in arbitrary depth

Author: CLAMOND, Didier

Affiliation: Laboratory Jean Alexandre Dieudonné, Université Côte d'Azur, Nice, France.

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Short Abstract
A fast and accurate algorithm for arbitrary precision computation of steady surface gravity waves is presented. The method works for arbitrary depth, arbitrary wavelength and up to 99% of the maximum height.

Title: Critical conditions of direct initiation of detonation

Authors: Paul Clavin

Affiliation: Institut de Recherche sur les Phénomènes Hors Équilibre
Aix-Marseille Université, CNRS, Centrale Marseille

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Short Abstract
The understanding of the critical condition for initiating gaseous detonations by an energy source is improved by the study of the inner structure of curved detonations. The quasi-steady solutions in the parameter space "velocity-radius" form an attractor for the trajectories of the unsteady solutions. The critical dynamic of the detonation fronts, investigated around the leading edge of this attractor, enlightens the critical conditions.

Title: A case of information interplay between a particle and a wave

Authors: Y. Couder, E. Fort, M. Labousse, S.Perrard

Affiliation: Laboratoire MSC , Université Paris Diderot.

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Short Abstract
The investigation of dynamical systems has revealed the origin of the deep-rooted difference between waves and particles regarding temporal reversibility. In a non-dissipative chaos, the dynamic of waves remains time reversible while for particles this reversibility is destroyed by the sensitivity to initial conditions. We will discuss the specific dynamical assets of a classical entity in which a particle is guided by a wave-field that serves as a memory repository.

Title: Human patterns

Authors: Kjartan Pierre Emilson

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Short Abstract

Since my Phd with Pierre Coullet, I haven't worked in Physics directly, but his vision and mode of thinking have followed me always and in everything that I do I tend to approach it from a point of view of patterns, emergence and robustness. In the last 15 years I have been making and studying patterns of people. Here is a short review of that.

Title: Random reversals of a vector field on a turbulent background

Authors: Stéphan Fauve

Affiliation: LPS, Ecole normale supérieure

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Short Abstract

Reversals of vector fields on a fluctuating background have been observed on many different scales. The magnetic field of the Earth has changed sign in a random way on geologic time scales. In many turbulent flows, a large-scale circulation also displays random reversals. We show that these reversals can be often modeled using low dimensional dynamical systems that describe a competition between modes with different symmetries. However, sometimes many modes are involved and a statistical approach is required.

Title: Elastic Instabilities in semiconductor film

Authors: Thomas Frisch, Guido Schifani

Affiliation: INPHYNI, CNRS UMR 7010, Université Côte d'Azur

e-mail of the speaker: Thomas.frisch@unice.fr

Short Abstract

The interplay between wetting effect and elastic instabilities is at the origin of the formation of quantum dots in semiconductor film. In this work, I will review and describe the dynamics and the morphology of quantums dots on an elastically strained semi-conductor solid film. I will address the question of their formation from a pattern formation point of view.

Title: Planar optics with metasurfaces

Authors: Patrice Genevet

Affiliation: ***Université Côte d'Azur, Centre de recherche sur l'hétéro-épitaxie et ses applications, Rue Bernard Grégory, 06560, Valbonne***

e-mail of the speaker: pg@crhea.cnrs.fr

Short Abstract:

Abrupt modifications of the fields across an interface can be engineered by depositing an array of sub-wavelength resonators specifically tailored to address local amplitude, phase and polarization changes. Such devices also dubbed Metasurfaces can achieve various sorts of optical functionalities for comprehensive wavefront engineering. In this presentation, we will introduce the concept and address the basic design rules for planar optical components.

Acknowledgments: PG acknowledges support from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant agreement no. 639109).

Title: Temporal Localized Structures in Passive Mode-Locked Semiconductor Lasers

Authors: P. Camelin[1], M. Marconi[1], J. Javaloyes[2], M. Giudici[1]

Affiliation: 1)Université Côte d'Azur, Institut de Physique de Nice, CNRS, Valbonne, France, 2) Universitat de les Illes Baleares, Palma de Mallorca, Spain

e-mail of the speaker: massimo.giudici@inphyni.cnrs.fr

Short Abstract

Passive mode-locking (PML) is a laser regime leading to a pulsed emission. We show that, when the cavity roundtrip is much larger than the medium timescales, these pulses may become *localized*, i.e. they can be individually addressed and tweezed by a proper parameter landscape. Manipulation and dynamics of these temporal localized structures is affected by the lack of parity symmetry of the system.

Title: De Robert Hooke au lycée des Eucalyptus

Authors: E. Guyon

PMMH, ESPCI Paris
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Short Abstract

The title refers to two sites of the scientific cultural activities of Pierre, throughout the years, from the *Hooke's hall of science* within the University to the *cité de la géométrie* in a college of Nice . It also honors the memory of this giant experimental scientist, who was Curator of experiments at the Royal Society, and is a reference for all of us.
Pierre has always been a precious contact in my activities in interactive science museology such as a large exhibition on non linearities in continuum mechanics and a actual project on *the elegance of materials*, we are developping at ESPCI (Paris).

Title: Bifurcating quasipatterns in Bénard-Rayleigh convection

Author: Gérard Iooss

Affiliation: IUF and Université Côte d'Azur, CNRS, LJAD, France

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Short Abstract

Joint work with B. Braaksma (Groningen). We prove the existence of bifurcating quasipatterns, invariant under horizontal rotations of angle $\pi/4$, in the steady Bénard-Rayleigh convection problem. There is a small divisor problem for $q/4$

Our solution is approximated by a Gevrey series (divergent in general). We show where are the new difficulties with respect to the Swift-Hohenberg model, and how to solve the existence problem via a Nash-Moser process, using the method of Berti et al 2010.

Title: Pattern formation in freezing droplets

Authors: Christophe Josserand[1], Thomas Séon[2] and Virgile Thievenaz[2]

Affiliation: 1- LadHyX, CNRS & Ecole Polytechnique, 2-Institut D'Alembert, CNRS & Sorbonnes Universités

e-mail of the speaker: christophe.josserand@polytechnique.edu

Short Abstract

When a drop impact on a very cold solid substrate, it spreads rapidly and is then sticked on the plate by the slower freezing of the liquid. It leaves us with a kind of pancake formed by a growing frozen layer on top of which a liquid layer can retract, leading to different final frozen patterns. In addition to this dynamical morphogenesis, further thermal retaction of the ice leads to the formation of high elastic stress that can lead to the formation of diverse crack patterns og the pancake. We will describe the different regimes of these patterns and explain their formation using simple energy balance arguments.

Title: Gravitational Waves and Turbulence in the Early Universe

Authors: Sébastien Galtier and Sergey Nazarenko
(underline the name of the speaker).

Affiliation : Institut de Physique de Nice, CNRS, Université de la côte d'azur.

e-mail of the speaker: S.V.Nazarenko@warwick.ac.uk

Short Abstract: Gravitational waves are spacetime ripples predicted by Einstein in 1916 and experimentally observed last year by the the Laser Interferometer Gravitational-Wave Observatory (LIGO) - a work recognised by the 2017 Nobel Prize in Physics. In my talk I will describe a statistical theory of interacting gravitational waves derived from the vacuum Einstein equations, and I will discuss some interesting scaling solutions of this theory and their possible significance for the Early Universe.

Title: Pattern Universes

Authors: Alan C Newell and Shankar Venkataramani

Affiliation: Department of Mathematics, University of Arizona

e-mail of the speaker: anewell@math.arizona.edu

Short Abstract

We connect the invariant topological indices (integer multiples of 1/2, 1/3 and 1) of loop defects with the condensation of the sectional Gaussian curvatures of phase surfaces. Motivated by the natural appearance in patterns of "quarks" and "leptons", we ask if there are further analogues in "pattern universes" with the many features familiar in orthodox cosmology. We find candidates for analogues of dark matter, dark energy, fine structure relations and inflation. We associate dark matter with the energy density in the pattern field and show that it leads to galactic star rotation speeds consistent with observation.

Title: Fluid approaches for sub-ionic turbulence in space plasmas

Authors: T. Passot, P.L. Sulem, E. Tassi, D. Laveder

Affiliation: Laboratoire Lagrange, UCA, Observatoire de la Côte d'Azur, Nice.

e-mail of the speaker: thierry.passot@oca.eu

Short Abstract

Heliospheric turbulent magnetized plasmas involve complex physical phenomena with several characteristic spatial and temporal scales breaking scale invariance. To address questions such as the partitioning of turbulent energy into linear and nonlinear waves or coherent structures, and to study the mechanisms of energy dissipation, fluid models have been developed and numerically integrated, for scales ranging from the ion to the electron scales, taking into account Landau damping as well as ion finite Larmor radius corrections. It will be shown that ion Landau dissipation can break the universality of turbulence, making the energy spectrum steeper while still allowing for power laws. At scales close to the electron inertial length, gyrofluid models including electron inertia are suited to study the role of magnetic reconnection in driving sub-ion-scale fluctuations. Phenomenological predictions on energy spectra and cascade directions within such models will be presented.

Title: Regarder autour de nous et tenter de comprendre. En hommage à l'ami Pierre Coullet

Author: Yves Pomeau, Martine Le Berre

Affiliation: University of Arizona (US) et Ladhyx, Polytechnique, Palaiseau.

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Short Abstract

Parmi toutes les formes naturelles que nous pouvons admirer, les arbres figurent en bonne place, et ils on inspirés de grands artistes dont Le Lorrain au premier rang.Le tronc des arbres ont une forme remarquable, larges à la jonction avec le sol, il s'élance vers le haut en s'amincissant. Cette forme s'explique par la contrainte opposée par le sol à la croissance radiale près de la surface du sol. La même idée permet d'expliquer l'instabilité azimutale qui fait onduler cette jonction avec le sol

Title: Extremely large velocity gradients in turbulent flows.

Authors: Alain Pumir

Affiliation: Laboratory de Physique, Ecole Normale Supérieure de Lyon and CNRS

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Short Abstract

The presence of extremely large velocity gradients is a hallmark of turbulent flows at very high Reynolds numbers. I will discuss the mechanism leading to the formation of very large gradients in the fluid equations. I will also present recent relevant experimental and numerical results.

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Title: Flow and nonlinearities inside the liquid foam microchannels

Authors: A. Cohen, N. Fraysse, J. Rajchenbach, Y. Bouret, M. Argentina, C. Raufaste

Affiliation: Physics Institute of Nice, Université Côte d'Azur

e-mail of the speaker: raufaste@unice.fr

Short Abstract

Plateau borders are the liquid microchannels found at the intersection between three bubbles in liquid foams. Surprisingly, these unbounded channels are not subject to the Rayleigh-Plateau instability due to a negative effective surface tension. We probe their stability using several types of perturbation and show that their relaxation triggers inertial flows characterized by strongly nonlinear features.

Title: Anatomy of vortex reconnection

Authors: Sergio Rica

Affiliation: Universidad Adolfo Ibáñez Santiago, Chile

e-mail of the speaker: sergio.rica@gmail.com

Short Abstract
In this talk I will discuss several aspects of vortex reconnection in the three dimensional nonlinear Schrödinger equation.

Title: Kindergarten mathematics

Authors: Emmanuel Risler

Affiliation: Institut Camille Jordan, INSA de Lyon, Université de Lyon.

e-mail of the speaker: emmanuel.risler@math.cnrs.fr

Short Abstract
I will present three mathematical results I proved thanks to ideas of Pierre Coullet. Their proofs are not especially difficult or technical, but a nice feature they share is that they say simple things on the real world, to the extent that they may be explained (at least the underlying phenomenology if not the results themselves) to young children: “Kindergarten mathematics”.

Title: Olfactory Navigation

Authors: Agnese Seminara, David Gire, Venkatesh Murthy

Affiliation: INPHYNI, CNRS, Université Côte d'Azur

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Short Abstract

I will discuss olfactory navigation in mice, focusing on their ability to shift between multiple decision-making strategies, to strike a balance between flexibility and efficiency. Our behvioral experiments show that mice are able to navigate to odor sources using naturally fluctuating airborne odor cues. I will discuss the computational challenges involved in tracking a turbulent odor to its source.

Title: Transport Closure Equations for Studying Tokamak-plasmas in Turbulent Regime

Authors: Giorgio Sonnino,

Affiliation: Université Libre de Bruxelles, Physics Department

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Short Abstract

I shall briefly recall the main results of the *Thermodynamical Field Theory* (TFT), the properties of the Lie-group associated to the *Thermodynamic Covariance Transformations* as well as the first success story of this theory (application of the TFT to collisional Tokamak-plasmas). I shall also introduce the transport equations that are currently applied for analysing Tokamak-plasmas in turbulent regime and the Hamiltonian formulation of the TFT (by using the field formalism introduced by De Donder-Weyl).

Title: Extreme events and their indicators in nonlinear dynamics

Authors: Jorge R. Tredicce,

Affiliation: Institut de Sciences Exactes et Appliquées de la Nouvelle Calédonie (ISEA) - Université de la Nouvelle Calédonie (UNC) - Noumea

e-mail of the speaker: jorge.tredicce@inln.cnrs.fr

Short Abstract
We make a short review about the processes generating extreme events in nonlinear dynamical systems and we discuss the possibility of predicting them.

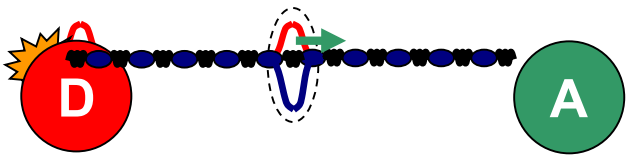
Title: Supersonic soliton electron surfing along an-harmonic molecular wires: truth and consequences

Author: Manuel G. Velarde

Affiliation: Instituto pluridisciplinar-ucm, Madrid, Spain

e-mail of the speaker: mgvelarde@pluri.ucm.es

Short Abstract
The simplest chemical act corresponds to electron (upper red curve) transfer to a chosen site (A-acceptor).



This can be achieved e.g. by electron surfing on a supersonic an-harmonic crystal lattice soliton (lower blue curve; red and blue curves bound together moving from D-donor to A). This concept also permits a field effect transistor having quite low heat dissipation.

Title: In P. Coullet's (early) style: A deterministic dynamics leading to broad statistics; Node dynamics at the border of liquid sheets.

Authors: E. Villermaux

Affiliation: Aix Marseille Université, Irphe

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Short Abstract

We study the intrinsic dynamics of cusps, or indentations, moving along a liquid sheet border, and characterize their ensemble statistics. These cusps are known to typically move along a sheet border, to present an asymmetry, and to be distributed in size around a mean. We show why an heterogeneous assembly of cusps travelling along a sheet rim occurs spontaneously, why big and small cusps coexist at the same time and, more precisely, we establish the specific link between the microscopic dynamics directing their motion, and the ensemble averaged distribution of their sizes.

Title: Is elasticity necessary for elastic turbulence?

Authors: Emmanuel L.C. VI M. Plan, Stefano Musacchio, Dario Vincenzi

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Short Abstract

Elastic turbulence is a chaotic regime that emerges in low-inertia viscoelastic fluids when the elasticity of the fluid exceeds a critical threshold. We show that a regime comparable to elastic turbulence can also be generated in solutions of rigid polymers.