# French-Israeli conference : From Non-equilibrium to Turbulence and Soft Matter

27-28-29 March 2023. Laboratoire de Mathématique J.A Dieudonné, Nice.

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## List of participants

### Israel

Hillel Aharoni, Gregory Falkovich, Jay Fineberg, Raz Kupferman, Roee Leder, Yuke Li, Victor Lvov, Baruch Meerson, Michael Moshe, David Mukamel, Shmuel Rubinstein, Omri Shaltiel, Eran Sharon, Victor Steinberg

### France

Mokhtar Adda-Bedia, Elsa Bayart, Raphael Chetrite, Laurent Chevillard, Thomas Frisch, Uriel Frisch, Giorgio Krstulovic, Kirone Mallick, Sergey Narzarenko, David Paulovics, Benoit Roman, Javier Aguilar Sanchez, Robert Van Gorder, Dario Vincenzi

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## Schedule

| | **Monday**<br>Chairman : Sergey | **Tuesday**<br>Chairman : Dario | **Wednesday**<br>Chairman : Raphael |
|---|---|---|---|
| 8h45-9h30 | Welcome and coffee | J. A. Sanchez & Raphael Chetrite | Giorgio Krstulovic |
| 9h30-10h15 | David Mukamel | Roee Leder | Michael Moshe |
| 10h15-10h45 | Coffee and pastry | Coffee and pastry | Coffee and pastry |
| 10h45-11h30 | Uriel Frisch | Elsa Bayart | Kirone Mallick |
| 11h30-12h15 | Shmuel Rubinstein | Jay Fineberg | Raz Kupferman |
| 12h15-13h00 | Omri Shaltiel | Gregory Falkovich (online) | Victor Steinberg |
| 13h00-14h30 | Lunch | Lunch | Lunch |
| | Chairman : Mokhtar | Chairman : Laurent | Chairman : Thomas |
| 14h30-15h15 | Hillel Aharoni | Eran Sharon | Yuke Li |
| 15h15-16h00 | Dario Vincenzi | Benoit Roman | Robert Van Gorder |
| 16h00-16h45 | Baruch Meerson | Victor Lvov | **End** |
| 16h45-17h15 | Coffee and pastry | Coffee and pastry | |
| 17h15-18h00 | Laurent Chevillard | Thomas Frisch & David Paulovics | |
| 18h00-18h45 | Sergey Narzarenko | | |
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| 19h30 | Dinner | Dinner | |

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# Titles/Abstracts of talks

**Hillel Aharoni**–*Tunable Architecture of Nematic Disclination Lines*

**Gregory Falkovich**–*Multi-mode correlations in turbulence*

**Jay Fineberg**–*The Fundamental physics of the onset of frictional motion : How does friction start ?*

Recent experiments have demonstrated that rapid rupture fronts, akin to earthquakes, mediate the transition to frictional motion. Moreover, once these dynamic rupture fronts ("laboratory earthquakes") are created, their singular form, dynamics and arrest are well-described by fracture mechanics. Ruptures, however, need to be created within initially rough frictional interfaces, before they are able to propagate. This is the reason that "static friction coefficients" are not well-defined ; frictional ruptures can nucleate for a wide range of applied forces. A critical open question is, therefore, how the nucleation of rupture fronts actually takes place. We experimentally demonstrate that rupture front nucleation is prefaced by slow nucleation fronts. These nucleation fronts, which are self-similar, are not described by our current understanding of fracture mechanics. The nucleation fronts emerge from initially rough frictional interfaces at well-defined stress thresholds, evolve at characteristic velocity and time scales governed by stress levels, and propagate within a frictional interface to form the initial rupture from which fracture mechanics take over. These results are of fundamental importance to questions ranging from earthquake nucleation and prediction to processes governing material failure.

**Raz Kupferman**–*Incompatible Elasticity : Some Results and Some Open Problems*

Incompatible elasticity is a term coined in the 1950s to describe the continuum theory of elastic solids in the presence of defects ; the point of view, which was novel at that time, is that defects modify the intrinsic geometry of the body, making it incompatible with the ambient space. Incompatible elasticity has seen a renewed interest in recent years in the context of both natural and human-made systems, which can be viewed as metrically frustrated. From a mathematical point of view, incompatible elasticity can be described as a problem of optimally embedding one Riemannian manifold (the body) into another Riemannian manifold (the ambient space). In this lecture I will present the mathematical formulation of incompatible elasticity, review some recent results, such as incompatible plate and shell theories and the homogenization of defects, and mention some open problems.

**Roee Leder**–*TBA*

**Yuke Li**–*Mechanism of vorticity amplification by elastic waves in a viscoelastic channel flow*

**Victor Lvov**–*Theory of anisotropic superfluid 4He counterflow turbulence*

We develop an analytic theory of strong anisotropy of the energy spectra in the thermally-driven turbulent counterflow of superfluid 4He. The key ingredients of the theory are the three-dimensional differential closure for the vector of the energy flux and the anisotropy of the mutual friction force. We suggest an approximate analytic solution of the resulting energy-rate equation, which is fully supported by the numerical solution. The two-dimensional energy spectrum is strongly confined in the direction of the counterflow velocity. In agreement with the experiment, the energy spectra in the direction orthogonal to the counterflow exhibit two scaling ranges : a near-classical non-universal cascade-dominated range and a universal critical regime at large wave numbers. The theory predicts the dependence of various details of the spectra and the transition to the universal critical regime on the flow parameters.

**Baruch Meerson**–*Fluctuations of "Brownian bees" and of some other N-particle systems*

**Michael Moshe**–*TBA*

**David Mukamel**–*Transport and condensation of driven traces in a narrow channel*

**Shmuel Rubinstein**–*TBA*

**Omri Shaltiel**–*Experimental Measurements of Energy Currents in Rotating Turbulence*

**Eran Sharon**–*Locomotion of active gel sheets via curvature modulation*

**Victor Steinberg**–*New directions and discoveries in elastic instability and turbulence in viscoelastic channel flow*

**Elsa Bayart**–*When the onset of frictional sliding is affected by localized disorder*

**Raphael Chetrite**–*When the Physicist Mr Jourdain meets Martin Gale*

**Laurent Chevillard**–*A dynamical picture of the phenomenology of fluid turbulence.*

**Thomas Frisch**–*Superfluid flow along a corrugated wall*

In my talk, I will present results obtained by the numerical simulations of the Gross-Pitaevskii equation (nonlinear Schrödinger equation) in two spatial dimensions along a corrugated wall made of a sinusoidal perturbation. I will show that there exists a critical velocity beyond which vortex nucleation occurs and that this phenomenon may lead to a complex spatio-temporal dynamic which couples vortices and waves. A phase diagram (velocity, corrugations amplitude) will also be presented.

**Uriel Frisch**–*TBA*

**Giorgio Krstulovic**–*TBA*

**Kirone Mallick**–*TBA*

**Sergey Narzarenko**–*Formation of zonal jets as a Bose-Einstein condensation process*

Zonal jets in geophysical fluids and in fusion plasmas are often mentioned together because some important basic mechanisms of their formation and nonlinear dynamics can be understood within the same nonlinear PDE - the Charney-Hasegawa-Mima equation. I will explain how formation of the zonal jets is similar to a Bose-Condensation process which,

in nonequilibrium settings, takes the form of an anisotropic inverse cascade of turbulent energy. I will explain how presence of an additional invariant – zonostrophy – makes the nonequilibrium cascading states anisotropic, and how it makes the condensation phase diagram two-dimmensional. Finally, I will explain how the zonal jets regulate the drift and QG turbulence and lead to formation of turbulent transport barriers.

**David Paulovics**–*Dynamics of Frost Propagation on Breath Figures*

**Benoit Roman**–*Geometry for thin plates : tearing and morphing*

**Javier Aguilar Sanchez**–*Endemic infectious states below the epidemic threshold and beyond herd immunity*

**Robert Van Gorder**–*Understanding the influence of temporal and spatial heterogeneity on diffusive instabilities leading to pattern formation*

**Dario Vincenzi**–*TBA*

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