Miniworkshop Physics of Matter

19 july 2022

Aula Magna Enric Casassas

Chair: Pietro Tierno

9:00 - 9:15	Welcome words: A. Diaz
9:15 – 9:40	M. Carmen Miguel
9:45 – 10:10	Eduard Vives
10:15 – 10:40	Sergi Granados Leyva
10:45 – 11:10	Jordi Ortín

Coffee break + discussions (20 min)

11:30 – 11:55	Levis Demian
12:00 – 12:25	Pietro Tierno
12:30 – 12:55	Alexis de la Cotte
13:00 – 13:25	Ramon Planet
13:25 - 13:30	Closing remarks

Lunch

Author

Maria Del Carmen Miguel Lopez

Title

Collective motion and consensus decision-making in social animal groups

Abstract

Real animals process a broad variety of social and environmental stimuli and perform complex stochastic decision-making processes to eventually coordinate their behavior, since coordination and cooperation are often crucial to their survival and reproductive success. Despite the rich ethological diversity, the ubiquity of collective behavior in very disparate systems suggests the existence of some underlying principles that transcends the peculiarities of individuals and species. In particular, collective motion is a beautiful example of self-organization and collective decision-making, in natural far-from-equilibrium systems. It is observed in a broad range of living systems, from bacterial colonies to the spectacular form of wildebeest herds crossing deserts in Africa.

Here we present modeling results where we apply common statistical physics techniques to characterize collective motion in social animal systems. Collective motion implies collective decision-making, a process which occurs daily in the lives of many group living animals. Understanding how consensus is reached, understanding who, if any, has any influence and the mechanisms by which information and preferences are integrated, poses a fundamental challenge in this research field. For instance, we observe that speed acts as a modulator of collective ordering and promotes the occurrence of behavioral changes at the individual level, which may by transmitted to the group, triggering intermittent avalanche-like behavior. We compare some of our modeling results with empirical observations of fish schools of black neon tetra swimming in a lab tank. Individual fish speeds, compatible with a burst-and-coast behavior, are synchronized at the global level, resulting in a quasi-periodic oscillation pattern of speed over time. Changes in global polarization are positively correlated with changes in average speed with a characteristic time lag, and both quantities tend to oscillate with the same effective period. Modeling results obtained so far appear to be in qualitative agreement with experimental observations in this schooling fish, and hint at temporal speed variations as an effective mechanism to control heading rearrangements and, thus, to eventually control polar order in social animal dynamics.

Author

Eduard Vives

Title

Avalanche Dynamics in First Order Structural Transitions and its influence on Caloric Effects

Abstract

Solids with structural first-order phase transitions are candidates for elastocaloric refrigeration due to its large latent heat and the fact that applying a mechanical stress is relatively easy compared to the alternatives based on electric or magnetic fields.

For the case of alloys exhibiting martensitic transitions, it is known that the dynamics proceeds by avalanches: its discontinuous in time and highly inhomogeneous. This can have deep implications in the design of devices, especially in small size and high frequency actuators.

In this short talk I will present some recent experimental results on the dynamics of martensitic transitions in Cu-based alloys, obtained by Acoustic Emission detection, optical imaging of strain maps and infrared imaging. These techniques allow to track the position of the moving interface fronts and the corresponding heat sinks and sources.

References:

Benoît Blaysat, Xavier Balandraud, Michel Grédiac, Eduard Vives, Noemi Barrera, and Giovanni Zanzotto, *Concurrent tracking of strain and noise bursts at ferroelastic phase fronts*, Communications Materials **1**, 3 (2020).

Lucia Ianniciello, Michela Romanini, Lluís Mañosa, Antoni Planes, Kurt Engelbrecht, and Eduard Vives, Tracking the dynamics of power sources and sinks during the martensitic transformation of a Cu–Al–Ni single crystal, *Appl. Phys. Lett.* **116**, 183901 (2020).

Guillem Capellera, Lucia Ianniciello, Michela Romanini, and Eduard Vives, Heat sink avalanche dynamics in elastocaloric Cu–Al–Ni single crystal detected by infrared calorimetry and Gaussian filtering, *Appl. Phys. Lett.* **119**, 151905 (2021).

Authors

Sergio Granados Leyva and Ignacio Pagonabarraga

Title

Capillary imbibition in lubricant coated channels and hydrodynamics in driven colloidal matter

Abstract

Our group carries computational and theoretical research in different fundamental topics regarding capillary and fluid mediated interactions in colloidal systems. Capillary is a never-ending source of biological and technological inspiration. Oil recovery through porous rocks [1] and inkjet printing [2] are examples of capillary based phenomena. Surface tension is able to displace air in a glass tube [3], can also promote spongeswelling [4], lead to biological mechanisms of water regulation [5], or control the coalescence of wet hair bundles [6, 7]. In the last decade, huge efforts are being made to design new responsive superhydrophobic materials, capable of avoiding pinning for anti-icing and antibiotic purposes. Biology provided inspiration for one of the most popular designed surfaces: Nepenthes is a carnivorous plant genus that traps insects by means of a microtexture that, when wet, creates a slippery, inescapable surface [8]. Based in this idea, Slippery Liquid-Infused Porous Surfaces (SLIPS) are texturized surfaces that, when impregnated by a lubricant oil, provide excellent superhydrophobic properties [9–11]. However, capillary displacing of a fluid phase by a more viscous one in a confined lubricant coated surface remains still a fundamental problem to be adresed. I will describe how these lubricant coated surfaces could speed-up imbibition processes and even modify the typical exponent obtained in absence of the lubricant.

I will also consider the role of hydrodynamic interactions (HIs) to induce collective motion of driven colloidal particles on a periodically textured substrate. HIs are known to be determinant for the dynamics of a variety of suspensions [12–14]. In ratchet transport systems, which are widespread in physics and biology, the effect of such HIs have been often overlooked. A theoretical model, and a simulation approach based in Brownian Dynamics will be introduced in order to characterise the role of HIs. The outcome of the experiments will be compared to the simulations, to show that HIs are able to resynchronise the colloids with the travelling wave induced by the textured substrate, producing a net increase of the average colloidal speed. The competition of HIs with dipolar interactions, lead to rhombic-like structures mediated by the underlying substrate symmetry [15].

References

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Author

Jordi Ortin

Title

Complex fluids and Complex flows

Abstract

In this talk I present the current research lines of the laboratory of Nonlinear Physics, and focus on our ongoing and future research projects.

The first part deals with Stokes layers, and their key role in the oscillatory flow of complex (non-Newtonian) fluids, particularly at large elasticity numbers. I will present the experimental results obtained in the lab for wormlike micellar solutions and xanthan gum solutions, and discuss them in terms of their rheological response. Then I will publicize our project of extending this research to yield-stress fluids (carbopol).

The second part deals with two-phase displacements of simple fluids in disordered environments. This is a challenging multiscale problem, in which capillary processes at the small disorder scales behave cooperatively to govern the flow at continuum and large scales. I will present our recent results on hysteresis, memory and energy dissipation in this problem, and outline our future research line

Author

Demian Levis

Title

Collective behaviour of driven, and active, soft matter

Abstract

In this talk I will first give a quick overview of our last results in order to smoothly introduce our ongoing projects and identify the key challenges for the near future.
The aim our current research is to understand the general mechanisms behind non-equilibrium phase transitions triggered by activity, or self-propulsion, and their ability to self-organize into non-equilibrium patterns at large time and length scales. I will present some simple model systems we deal with as a starting point to try to establish the statistical mechanics of collections of interacting active and driven units. I will first focus on 2D phase transitions, discuss the properties of topological defects in this new context, and outline the questions that remain open (and that interest me the most). Then, I will talk about how glassy physics might be affected by activity and what we've learned about it over the last two years. And finally, I will move to chiral soft matter, and show how chirality can be used to control pattern formation, as well as triggering novel transport and phase transition phenomena. Hopefully, I will also have some time to quickly mention applications to classical problems in complex systems such as synchronisation and epidemic spreading.

Author

Pietro Tierno

Title

From driven to active colloids: research in the Magnetic Soft Matter group

Abstract

In this talk I will give a general overview of the different research activities that are running in the magnetic soft matter group, at the university of Barcelona. The work of the group is mainly experimental and centered on investigating the collective dynamics of microscopic colloidal particles dispersed in a fluid and driven by external fields. These are generated either by magnetic fields such as externally modulated thin ferromagnetic films or with optical tweezers obtained from fast scanning laser beams. We combine different types of external actuations to manipulate microscopic colloids, forcing them to translate at a constant speed or use them as a model system to address generic phenomena in condensed matter, including depinning, rectification effects, directional locking, melting, geometric frustration and so on. More details will be given in four research lines:

1. Ratcheting colloids above periodic magnetic potentials [1].

2. Colloids driven colloids by optical potential landscapes [2].

3. Active particle systems both chemically [3] and magnetically [4] driven.

4. Artificial colloidal ice systems for geometric frustration phenomena [5].

References:

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Author

Alexis de la Cotte, Alberto Fernadez-Nieves

Title

Soft Matter in the AFN Lab

Abstract

We review in this presentation some of the topics we work on, including: (i) polymer gels and their deformations, (ii) colloidal suspensions, scattering, rheology and glasses/crystals, (iii) liquid crystals, both passive and active, and their defects, (iv) grains in columns, (v) microfluidics, (vi) active living antsy-matter.

Author

R. Planet, C. Anderson, I. Zamorano, and A. Fernandez-Nieves

Title

The uncanny weight of granular columns

Abstract

Granular matter exhibits unusual mechanical properties. For example, when filling a cylindrical column with grains, the weight measured at the bottom of the column does not scale linearly with added mass, but asymptotically saturates towards a constant value. This observation is well-known in the granular matter community; it is referred to as the "Janssen's effect". The weight is partially supported by the lateral walls through frictional interactions with the grains. However, it has been recently observed that the weight measured at the bottom can become larger than the total added mass when the columns are sufficiently small compared to the diameter of the grains. In this talk, we will review this "reverse" Janssen effect, and present new results using grains with different geometry. We find that columns filled with non-spherical particles also display the overshoot in weight observed with spherical grains, but now the compressive forces responsible for the reverse Janssen behavior are restricted to a narrower range in depth; we argue that packing effects are behind the quantitative differences between spherical to non-spherical grains.