Interaction Disorder Elasticity GDR

– 28-30/11/2022, Grenoble –

	Monday 28/11	Tuesday 29/11	Wednesday 30/11
		Interfaces	***Plasticity***
09:00		C. Cottin-Bizonne	A. Tanguy
09:30		S. Santucci	L. Truskinovsky
10:00		Coffee break	Coffee break
10:30		5 contributed presentations	5 contributed presentations
11:00			
11:30			
12:00		Lunch	Lunch
12:30			
13:00	Welcoming		
13:30		***Rheology***	
	Quantum	F. Graner	
14:00	V. Ros	C. Barentin	
14:30	T. Maimbourg	Coffee break	
15:00	Coffee break	7 contributed presentations	
15:30	6 contributed presentations		
16:00			
16:30			
17:00	Flash talks	Coffee break	
17:30		Poster session	
18:00			
18:30			
Evening		Conference dinner	

Invited presentations: 25+5 minutes
Contributed presentations: 13+2 minutes

Monday 28/11 afternoon – ***Disorder in quantum and statistical mechanics systems***

- Valentina Ros (LPTMS, Paris-Saclay)
- Thibaud Maimbourg (IPhT, Saclay)
- + 6 contributed talks

14:00 - Quantum dynamics with disorder: localization, and how it is (and it is not) related to glassiness - Valentina Ros (LPTMS, Paris-Saclay)

In this talk I would like to discuss localization phenomena in quantum systems subject to sufficiently strong disorder. I will first stress in which sense localization is fundamentally different with respect to glassiness. I will then comment on how concepts related to glasses (such as freezing transitions) nevertheless emerge naturally from the theoretical description of localized systems. In fact, when quantum dynamics of disordered systems is treated within certain approximations (already introduced by P. W. Anderson in his seminal work of 1958), interesting connections emerge with a simple model of glasses, the directed polymer in disordered medium. If time permits, I will discuss more recent work analyzing the interplay between localization and glassiness in a model in which the local disorder is characterized by different fluctuation timescales.

14:30 - Low-temperature anomalies in glasses from the mean-field viewpoint - Thibaud Maimbourg (IPhT Saclay)

The physics of amorphous solids at low temperatures differs strikingly from that of their crystalline counterparts. Prominent changes are observed in e.g. vibrational modes or the specific heat below 10 K. In the last 50 years, phenomenological non-interacting models have given remarkable agreement with experimental data while leaving many fundamental questions unresolved. A distinct line of research has been to solve interacting mean-field models in order to gather physical insight rooted in first principles, with sometimes conflicting results or key ingredients missing.

I will present a summary of this quest and focus mostly on a recently proposed mean-field model which contains many desirable features. Unlike previous attempts, it hosts localized vibrational modes with the correct density of states, and pseudo-gapped nonlinear excitations. The latter entail a new type of replica symmetry breaking to a marginally-stable glass phase (with a long-sought critical point in a field at zero temperature). The study of its quantum thermodynamics relates these two types of low-energy excitations to both Debye (harmonic) and two-level system (instantons) physics.

15:00 - 15:30 Coffee break

15:30 - Non-Anderson disorder-driven quantum transition in nodal semimetals - Andrei Fedorenko (ENS Lyon)

The recent discovery of materials, such as Weyl and Dirac semimetals, whose low-energy properties are described by three-dimensional relativistic fermions opened fascinating opportunities to study physical phenomena which have never been accessible before. Among these phenomena is a remarkable disorder driven quantum transition from the semimetal towards a diffusive metallic phase characterized by a finite density of states at the band crossing. This transition is different from the Anderson localization transition but exhibits many similar properties such as multifractality of critical wave functions and broad distribution of density of states. The existence of surface states such as Fermi arcs also leads to new rich surface critical phenomena. I will review recent progress in understanding different aspects of this transition including multifractality and surface criticality. I also show how the functional renormalization group can be useful for studying this disordered quantum system.

[1] T. Louvet, D. Carpentier, and A. A. Fedorenko, Phys. Rev. B 94, 220201(R) (2016).
[2] I. Balog, D. Carpentier, and A. A. Fedorenko, Phys. Rev. Lett. 121, 166402 (2018).
[3] E. Brillaux, D. Carpentier, and A. A. Fedorenko, Phys. Rev. B 100, 134204 (2019).
[4] E. Brillaux and A. A. Fedorenko, Phys. Rev. B 103, L081405 (2021).

15:45 - Bath induced phase transition in a Luttinger liquid - Saptarshi Majumdar (LPTMS, Paris-Saclay)

In this talk, I will talk about our study of an XXZ spin chain, where each spin is coupled to an independent ohmic bath of harmonic oscillators at zero temperature. Using bosonization and numerical techniques, we show the existence of two phases separated by a Kosterlitz-Thouless (KT) transition. At low coupling with the bath, the chain remains in a Luttinger liquid phase with a reduced but finite spin stiffness, while above a critical coupling the system is in a dissipative phase characterized by a vanishing spin stiffness. We argue that the transport properties are also inhibited: the Luttinger liquid is a perfect conductor while the dissipative phase displays nite resistivity. Our results show that the effect of the bath can be interpreted as annealed disorder inducing signatures of localization.

16:00 - Hidden non-equilibrium phase transition to temporal oscillations in a disordered mean-field spin model - Laura Guislain (LIPhy, Grenible)

We study the effect of introducing quenched disorder on a non-equilibrium mean-field spin model exhibiting a phase transition to an oscillating state in the absence of disorder. In this disordered version of the model, usual order parameters no longer carry the signature of the phase transition to an oscillating state. However, a non-trivial distribution of the overlap of spin configurations is observed, a phenomenon reminiscent of a continuous replica symmetry breaking as reported in mean-field spin-glasses. We show that the non-trivial overlap distribution is not due to the presence of disorder, but to the presence of hidden temporal oscillations. These oscillations can be explicitly observed by considering specific observables, which require a perfect knowledge of the microscopic disorder. We also show that a signature of oscillations can be detected even with a partial knowledge of the microscopic disorder.

16:15 - Assessing the predictive Power of GPS data for aftershock prediction in Southern California - Vincenzo Maria Schimmenti (LPTMS, LISN)

In this work we use simple machine learning models to characterize the usability of GPS data in predicting aftershocks of earthquakes occured in Southern California in the last two decades.

16:30 - Elasticity, Facilitation and Dynamic Heterogeneity in Glass-Forming liquids - Misaki Ozawa (LIPhy, Grenoble)

We study the role of elasticity-induced facilitation on the dynamics of glass-forming liquids by a coarse-grained two-dimensional model in which local relaxation events, taking place by thermal activation, can trigger new relaxations by long-range elastically-mediated interactions. By simulations and an analytical theory, we show that the model reproduces the main salient facts associated with dynamic heterogeneity and offers a mechanism to explain the emergence of dynamical correlations at the glass transition. We also discuss how it can be generalized and combined with current theories.

16:45 - What is the appropriate field theory? - Kay Wiese (LP-ENS, Paris)

No computation can be performed without first identifying the underlying field theory. For some physical systems this is challenging. Here we give examples where the effective action for a class of disordered systems is measured in simulations and experiments. This allows one to identify, and finally construct, the appropriate field theory. While we apply these ideas to the quenched Edwards-Wilkinson and quenched KPZ equation, the method may be useful more generally.

17:00 - Flash Talks

Tuesday 29/11 morning – ***Interfaces (disordered, biological, active etc.)***

- Cécile Cottin-Bizonne (ILM Lyon)
- Stéphane Santucci (ENS Lyon)
- + 5 contributed talks

9:00 - Actives interfaces - Cécile Cottin-Bizonne (ILM Lyon)

Active matter systems, consisting of self-propelled particles, exhibit rather striking dynamical properties which understanding has attracted considerable effort in recent years. I will present some results obtained in our group, with a monolayer of sedimented active colloids. If at low density they behave as perfect hot gas, at intermediate densities we have observed and characterized a new collective phenomenon: the formation of clusters. In the dense regime, we have identified an unexpected behavior as the activity level rises, that cannot be described by a simple increase in temperature. I will finish with a teaser on our studies on the dynamics of interfacial swimmers, self-propelled objects lying between two fluid phases, and more precisely the spontaneous motion of camphor particles at a liquid-gas interface.

9:30 - Self-Heating Process in material failure: How cracks are hot and cool - Stéphane Santucci (ENS Lyon)

Temperature is a determining parameter to understand material failure. For instance, when a material is loaded below its rupture threshold, thermally activated processes [1,2] control the slow subcritical rupture dynamics and its transition towards a sudden catastrophic failure. In the case of polymers, temperature has also a strong impact on the mechanical properties, especially around the glass transition temperature, where elastic and loss moduli vary significantly. This can result in a complex and non-monotonic dependence of the fracture energy with crack speed and temperature that may lead to rupture instabilities [3]. These instabilities may result from the non- uniform temperature field at the crack tip obtained from the balance of heat production at a given crack speed with heat diffusion determined by the material thermal properties [4].
We have recently developed a different approach combining the effect of heat diffusion within a subcritical rupture model [1,2,5], where temperature only affects the thermally activated rupture process but not the material mechanical properties [6]. This model manages to capture the fracture energy dependence on crack speed from very slow up to very fast crack dynamics that is responsible for the stick-slip rupture instabilities, and predicts that temperature rise at the crack tip of several 1000 K could occur in the fast rupture regime, consistent with a full spectral measurement of the black-body radiation.

[1] S. Santucci, L. Vanel, and S. Ciliberto,Phys. Rev. Lett. 93, 095505 (2004)
[2] L. Vanel, S. Ciliberto, P.-P. Cortet and S. Santucci,J. Phys. D: Appl. Phys., vol. 42, p. 214007, (2009)
[3] V. De Zotti, K. Rapina, P.-P. Cortet, L. Vanel, and S. SantucciPhys. Rev. Lett. 122, 068005 (2019)
[4] R. Toussaint, O. Lengliné, S. Santucci, T. Vincent-Dospital, M. Naert-Guillot, K.J. Måløy,Soft Matter 12 5563 (2016)
[5] T. Vincent-Dospital, A. Cochard, S. Santucci, K.J. Måløy, R. Toussaint,Scientific Reports 11 (1), 1-16 (2021)
[6] T. Vincent-Dospital, R. Toussaint, S. Santucci, L. Vanel, D. Bonamy, L. Hattali, A. Cochard, E. Flekkøy K. J. Måløy, Soft Matter, 16, 9590 (2020)

10:00 - 10:30 Coffee break

10:30 - Crack propagation in heterogeneous materials. A phase field study. - Hervé Henry (Physique de la Matière Condensée, Polytechnique)

Crack propagation in a matrix with either soft or hard inclusions has been studied using a phase field model of crack propagation. The effects of heterogeneities of elastic constants on the propagation of a crack front in three dimensions will be discussed in the case of a single heterogeneities.Then the case of multiple heterogeneities organised on a network will be discussed.

10:45 - A new observable to measure the roughness of interfaces - Nirvana Caballero (DQMP, Geneva)

The framework of disordered elastic systems is one of the most powerful theoretical tools to asses the physics of multiple systems that span from ferromagnets to migrating biological cells. In this formalism, one assumes that the system can be described with a displacement field. This field can represent an interface position, the deformation of a vortex lattice or charge density waves in semiconductor devices, among others. By construction, this field is univalued and 'smooth', and the consequences of these approximations have not been yet fully explored. In this talk, I will present a new observable to meassure the roughness of displacement fields that can be beyond the elastic limit and can contain overhangs and other defects. From a theoretical point of view, this observable allows us to track the consequences of the elastic approximation in determining the scaling of the displacement field fluctuations. For experimental realisations of interfaces, it allows a more precise computation of the roughness since it does not require the determination of the interface position.

11:00 - Convergence of an elastic line propagating in a bi-periodic random potential - Jonathan Barès (LMGC, Montpellier)

Let's assume that a circular elastic line propagates in the revolution direction of a torus covered with a random potential. Whatever the driving speed, loading stiffness, range of interactions, frozen noise amplitude or torus dimensions, how long does it take for this line to converge to a perfectly cyclic behaviour? How is this convergence controlled?

11:15 - Contribution of the magnetic texture to domain-wall creep motion - Vincent Jeudy (LPS, Paris-Saclay)

We investigate the intriguing universal behaviors [1-4] of magnetic domain-wall driven by the spin-transfer torques of an electrical current, in thin ferromagnetic (Ga,Mn)(As,P) films with perpendicular magnetic anisotropy. While an elastic line moving in a random pinning disorder is usually sufficient to describe the thermally activated creep motion of domain-wall, we evidence a contribution of domain-wall magnetic texture.

[1] K.-W. Moon *et al.*, Phys. Rev. Lett. **110**, 107203 (2013).
[2] J. Ryu, S.-B. Choe, and H.-W. Lee, Phys. Rev. B **84**, 075469 (2011).
[3] J.-C. Lee *et al.*, Phys. Rev. Lett. **107**, 067201 (2011).
[4] R. Diaz Pardo *et al.*, Phys. Rev. B **100**, 184420 (2019).

11:30 - Universal critical exponents of the magnetic domain wall depinning transition - Sebastian Bustingorry (CSIC-UNIZAR and CNEA-Bariloche)

The depinning transition rules the low velocity response of domain walls in magnetic thin films. Understanding the depinning transition is key to unveil the role of disorder in magnetic systems. Here we present low-temperature results of magnetic-field-driven domain wall dynamics in a ferrimagnetic GdFeCo thin film with perpendicular magnetic anisotropy. Measurements performed in a practically athermal condition allow for the direct experimental determination of the velocity and correlation length exponents of the depinning transition. The whole family of exponents characterizing the transition is deduced, providing evidence that the depinning of magnetic domain walls is well described by the quenched Edwards-Wilkinson universality class.

Tuesday 29/11 afternoon – ***Rheology in active and soft matter***

- François Graner (MSC, CNRS & Univ. Paris Cité)
- Catherine Barentin (ILM Lyon)
- +7 contributed talks

13:30 - Dynamics of cellular materials: from foams to biological tissues - François Graner (MSC, CNRS & Univ. Paris Cité)

Liquid foams are made of two fluids : gas bubbles surrounded by water. Surprisingly, they display elastic and plastic behaviours which are supposed to characterise solid materials. They are model systems to understand disordered cellular materials (made of cells tiling the space), which behave simultaneously as solids and liquids. We investigate flows within geometries specifically designed to discriminate between models. We extend this approach to active cellular materials, in particular to collective movements of living cells.

14:00 - Simple ions control the mechanical properties of calcite gels via interparticle forces - Catherine Barentin (ILM Lyon)

Calcite is a mineral ubiquitous on Earth and in various applications. Suspending small 100 nanometer calcite particles in aqueous solution form a colloidal gel, behaving like a paste intermediate between an elastic solid and a viscous liquid. Characterizing its mechanical behavior, i.e. rheology, provides crucial information on the properties of mineral surfaces in solution, as well as on the structure and the complex physics of colloidal gels. In this talk, I will study the impact of the addition of simple ions on the mechanical properties of the
calcite gel.
In the first part, I will show that the addition of calcium hydroxide impacts drastically the elastic modulus and more importantly that, a minimum in elastic modulus is correlated to a maximum in the DLVO energy barrier. In the second part, I will show that the addition of sodium hydroxyde modifies the flows inside the calcite gels going from homogeneous to heterogeneous velocity profiles as the attraction between particles increases.

14:30 - 15:00 Coffee break

15:00 - Imaging three-dimensional (3D) foam flows in real time at the bubble scale using fast X-ray tomography - Benjamin Dollet (LIPhy, Grenoble)
Liquid foams are a model system in the field of rheology of soft amorphous matter, because their microstructural items, the bubbles, are of accessible scale and display well-defined elementary plastic rearrangements. However, 3D foams are opaque, which complicates the direct observation of their flow at the bubble scale; hence, most experiments have focussed on 2D systems. In this contribution, we show how fast X-ray tomography can be used to resolve in depth a 3D foam and image its flow at the bubble scale in real time. We illustrate the use of this technique on two experiments: (i) the flow in a convergent/divergent channel (like a hourglass), and (ii) a shear flow in a plate-plate rheometer. In the first configuration, comparing convergent and divergent channels

reveals that the flow is symmetric, but the bubble deformation is strongly asymmetric. We then show how the second configuration could be a model experiment to study well-controlled plastic flows of amorphous materials.

15:15 - Simulating the standard active-matter models with Monte Carlo methods - Juliane U. Klamser (L2C, Montpellier)

The physics of active matter is determined by the non-equilibrium dynamics of the constituent particles. While constructing a non-equilibrium Monte Carlo (MC) dynamics for active matter is straightforward, the question remains to what extent this discrete-time dynamics faithfully captures real-world/continuous-time active systems. We focus on a kinetic MC version for the simplest kind of active matter: persistently moving, non-polar, interacting particles. On the multi-particle level, the MC dynamics captures not only Motility-induced phase separation[1] but also features a non-equilibrium extension of the celebrated two-dimensional melting[2]. We show[3], however, that the continuous-time limit of existing MC dynamics[1,2] is ill-defined, leading to the vanishing of trademark behaviours of active matter such as the motility-induced phase separation, ratchet effects, as well as to a diverging mechanical pressure. We show[3] how mixing passive/uncorrelated moves with active/time-correlated ones regularises this behaviour, leading to a well-defined continuous-time limit. We propose new active kinetic MC algorithms whose continuous-time limits are the Langevin descriptions of the work-horse active-matter models, namely Active-Ornstein Uhlenbeck, Active Brownian, and Run-and-Tumbles particles. Reference [1]D. Levis and L. Berthier, Phys. Rev. E 89 (2014), 062301 [2]J. U. Klamser, S. C. Kapfer and W. Krauth, Nat Commun 9 (2018) 5045 [3]J. U. Klamser, O. Dauchot and J. Tailleur, Phys. Rev. Lett. 127 (2021), 150602

15:30 - Derivation of a continuum description of sheared jammed soft suspensions from particle dynamics - Eric Bertin (LIPhy, Grenoble)

Jammed soft suspensions exhibit a rich phenomenology under deformation, including the existence of a yield stress and non-monotonous stress relaxations. Starting from the microscopic particle dynamics, we derive using a set of approximations a continuum description in terms of the macroscopic stress tensor for given applied time-dependent deformations. This constitutive equation rooted in the microscopic dynamics qualitatively reproduces a number of salient features of the rheology of jammed soft suspensions, including the presence of a yield stress and non-trivial relaxation properties for time-dependent protocols.

15:45 - Mathematical and numerical modelling of collective cell movement - Nathan Shourick (LJK)

Epithelial cells organized in monolayers can migrate on a substrate, as observed in embryogenesis, tumor growth, or wound healing. Cells have a polarity, a preferred direction for active forces and motion, that tends to align with neighbor cells; this local coordination contributes to the emergence of collective migration at a larger scale. In close interaction with experiments in Lyon and Paris, we developed a mathematical model at tissue scale in the formalism of continuum mechanics to better understand the appearance of collective movement. Based on results of numerical resolutions, we will discuss the feedbacks between viscoelasticity, polarity and activity.

16:00 - Random organization with mediated interactions, Romain Mari (LIPhy, Grenoble)
Experiments of periodically sheared colloidal suspensions or soft amorphous solids display a transition from reversible to irreversible particle motion that, when analyzed stroboscopically in time, is interpreted as an absorbing phase transition with infinitely many absorbing states. In these systems, interactions mediated by hydrodynamics or elasticity are present, causing passive regions to be affected by nearby active ones. We show that mediated interactions induce a universality class of absorbing phase transitions distinct from conserved directed percolation, and we obtain the corresponding critical exponents. We do so with large-scale numerical simulations of a minimal model for the stroboscopic dynamics of sheared soft materials and we derive the minimal field theoretical description.

16:15 - Investigation of granular avalanches triggered by ultrasound - Xiaoping Jia (Institut Langevin, Paris)
An inclined granular bed begins to flow beyond a maximum angle (avalanche angle), and stabilizes again at a lower angle (angle of repose). At an angle less than the avalanche angle, the granular bed may also flow if subjected to an external disturbance. This is how, for example, certain landslides or rockfalls originate from vibrations linked to local seismic activity or even to distant earthquakes. If the phenomenon is known, it is still imperfectly understood (V. Durand et al, On the Link Between External Forcings and Slope Instabilities in the Piton de la Fournaise Summit Crater, Reunion Island?, J. Geophys. Res. 123, 2422 (2019)). In this talk, we shed a new light on this issue by laboratory experiments using ultrasound (J. Léopoldès, X. Jia, A. Tourin, and A. Mangeney, Triggering granular avalanches with ultrasound?, Phys. Rev. E 102, 042901(2020)). In these experiments, the granular bed consists of glass bead layers (d ~ 100 µm in diameter) with controlled thickness and deposited on a plane ultrasonic transducer with an inclined angle less than the avalanche angle. We observed a bifurcation of flows triggered by nanometer-amplitude ultrasound: (i) a stationary flow with a rate independent of the vibration amplitude when the inclination is slightly less than the avalanche angle, and (ii) a creep-like flow which stops with ultrasound turned off when inclined at a lower angle. In both cases, the ultrasound amplitude is too small to induce any macroscopic rearrangement of grains, instead, the ultrasound lubricates the grain contacts and reduce the interparticle coefficient of friction, leading to failure by the acoustic fluidization. This work should provide a better understanding of the triggering of landslides and rockfalls by seismicity.

16:30 - Long-life micro-balloons: Micro-bubble encapsulation by electrostatic templating with ionic surfactants (Stéphane Santucci, ENS Lyon)
Micro-bubbles display unique properties allowing the design of original functional fluids, relevant for many industrial processes and products. However, their disproportionation and coalescence limit severely their use. While encapsulating bubbles with hydrophobic colloids is commonly used to lessen such destabilizing aging effects, the interfacial interactions before particle attachment to the bubble surface remains poorly understood and difficult to control.
We propose here a robust micro-bubble encapsulation process, that goes beyond the so-called Pickering technique, using electrostatics as a driving force to guide either particles or polymerizable precursors (silicate anions) to the bubble surface. Taking advantage of attractive interactions between surfactant-laden charged bubbles and oppositely charged self-assembling species, our method produces micro-balloons with diverse protective shells that remain stable for years.

Considering heterogeneous electrostatic double-layer interactions, we can quantitatively predict critical particle surface potentials, required for complete encapsulation. Furthermore, the particle-based shells can be disintegrated with a pH adjustment, allowing for a controlled release of encapsulated payloads, while the glassy continuous silicate capsules are chemically resistant to pH changes. Finally, our process which can be equally applied to liquid droplets easily scales up for industrial developments.

17:00 - 17:30 Coffee break

17:30 - 19:30 Poster

Wednesday 30/11 morning – ***Amorphous vs. crystalline plasticity***

- Anne Tanguy (LaMCoS, INSA Lyon)
- Lev Truskinovsky (PMMH, ESPCI Paris)
- +5 contributed talks

9:00 - 10:00 Plasticity at small scale in amorphous and crystalline materials - Anne Tanguy (LaMCoS, INSA Lyon) & Lev Truskinovsky (PMMH, ESPCI Paris)

In two parallel talks, we will discuss the theory of plasticity in solids emphasizing the role of mechanical instabilities. In both amorphous materials and crystals plastic flow is supported by dissipative rearrangements. Such rearrangements are generally localized in amorphous plasticity while in crystal plasticity they may be de-localized. The large-scale thermo-mechanical plastic behaviour of both amorphous and crystalline solids depends on the temperature as well as on the strain rate. In amorphous plasticity an important role is also played by the preparation protocol and the atomistic composition, while in crystal plasticity, a similar role is played by the crystallographic structure and the orientation of the sample in the loading device. The similarities in the mechanical response of amorphous solids and crystals are numerous, including the phenomenon of steady state plastic yield, the formation of shear bands, vortex-type displacement fields, the development of scale free spatial complexity, the presence of power law distributed plastic avalanches and the possibility of brittle to ductile transition in shear. These and other related effects will be reviewed in the context of amorphous and crystal solids with the emphasis on the common origin of the underlying phenomena in purely mechanical instabilities.

10:00 - 10:30 Coffee break

10:30 - The fate of shear-oscillated amorphous solids - Ezequiel E. Ferrero (University of Barcelona ; CNEA Bariloche)

The behavior of shear-oscillated amorphous materials is studied using a coarse-grained model. Samples are prepared at different degrees of annealing and then subject to athermal and quasistatic oscillatory deformations at various fixed amplitudes. The steady-state reached after several oscillations is fully determined by the initial preparation and the oscillation amplitude, as seen from stroboscopic stress and energy measurements. Under small oscillations, poorly annealed materials display shear-annealing, while ultra-stabilized materials are insensitive to them. Yet, beyond a critical oscillation amplitude, both kinds of materials display a discontinuous transition to the same mixed state composed by a fluid shear-band embedded in a marginal solid. Quantitative relations between uniform shear and the steady-state reached with this protocol are established. The transient regime characterizing the growth and the motion of the shear band is also studied.

Chen Liu, Ezequiel E. Ferrero, Eduardo A. Jagla, Kirsten Martens, Alberto Rosso, Laurent Talon, The Journal of Chemical Physics 156, 104902 (2022), arXiv:2012.15310

10:45 - Interplay between dislocations and correlated stress environment in random alloys - Pierre-Antoine Geslin (INSA Lyon)

The study of random alloys is of large interest in metallurgical sciences due to the significant influence of solute solution strengthening on the yield stress. This solid solution strengthening is particularly taken advantage of in the recent development of high entropy alloys that contain multiple elements in comparable quantities. In these alloys, the proximity of atoms of different sizes leads to small displacements of atoms with respect to their lattice sites that are also called micro-distortions. These micro-distortions are accompanied by internal stresses that impede dislocation motion and are responsible for the solid solution strengthening. To investigate the influence of this solid solution on dislocation behavior, our work is articulated around two steps. We first developed an elastic model of random alloys where atoms of different sizes are modeled as elastic inclusions embedded in an isotropic elastic medium. This allows to derive analytical expressions for the mean-square displacements (that corresponds to the amplitude of micro-distortions) and for the mean square internal stress that impedes dislocation motion. Both quantities are found to be proportional to the variance of the atomic sizes, that is recognized as a key-parameter controlling the strength of high entropy alloys. Our model can be used not only to obtain the variance of the displacement and stress fields but also their spatial correlations. Surprisingly, we show that stress correlations are highly anisotropic despite the use of isotropic elasticity and the randomness of the alloy. The second step consists in using this correlated stress environment in a dislocation dynamics framework to derive the critical stress leading to the dislocation depinning. We show that the stress correlations are crucial to incorporate in the model in order to accurately predict the magnitude of solid solution strengthening operating on screw and edge characters in these concentrated random alloys. The numerical results allow us to critically assess the validity and the limitations of average models from the literature.

11:00 - Study of aftershocks at the lab scale - Ambroise Mathey (Institut de Physique de Rennes)

We are interested in the deformation of granular medium (non cohesive glass beads) and its plasticity, which is observed using an optical technique called Diffusive Wave Spectroscopy. Such a system can be considered as a model of athermal amorphous material. When a sample of beads is deformed beyond a certain point (4 ? 5%), the sample fails and a stationary regime arises. The deformation is then localized in shear bands separating the sample in solid blocks. Those shear bands behave very similarly to the way a seismic fault does. Indeed, localized slip events occur intermittently along the shear bands and the size distribution of those plastic events follows a power law. We also observe a memory effect, i.e. aftershocks after a considered mainshock that follows Omori's law. It makes our system a pretty good model to study earthquakes at the lab scale. I will present recent results showing that the aftershocks we observe are linked to a memory effect in deformation and not a time dependent effect.

11:15 - Mapping out the glassy landscape of a mesoscopic elastoplastic model - Dheeraj Kumar (PMMH, Paris)

We develop a mesoscopic elasto-plastic model to study the behavior of cyclically sheared amorphous solids. As a first step, we propose a simple protocol of `glass preparation' that helps us continuously tune the system's state from a very disordered fresh soft glass to a very aged hard glass. Initial glass states, ranging from soft to hard, are then subjected to various loading protocols under a quenched environment of disorder. The dependence of plastic behaviour under uniform mechanical driving is recovered. The evolution of plastic response under cyclic driving at different age and size is studied. Based on this, we make conclusions on the age and size dependence of the irreversibility transition. We also perform a rigorous study on the disorder-landscape of these glasses by projecting their mechanical response on transition graphs, which describe plastic deformation pathways under athermal quasi-static shear. A key topological property of these graphs known as strongly connected components, through their stability ranges, reveal the emergence of a phase-separation like process associated with the degree of annealing of the initial glass sample. Increasing the brittle nature of the initial glass manifests itself in breaking the landscape of dynamically accessible stable states into three distinct regions: one region centered around the initially prepared glass phase, and two additional regions, characterized by well-separated ranges of positive and negative plastic strains, which are accessible only from the initial glass phase by passing through the stress peak in the forward, respectively, backward shearing directions.

11:30 - How do dense systems of large persistence self-propelled particles relax? - Yann-Edwin Keta (L2C, Montpellier)

We employ activity-driven dynamics (ADD) to study the relaxation of dense systems of large persistence self-propelled particles on time scales large compared to the persistence time. On the time scale of the persistence time, the dynamics is intermittent: elastic branches in which the system moves collectively in response to changes in the self-propulsion forces are interrupted by instantaneous plastic events during which a subset of the system changes its local structure. On average, this dynamic is diffusive. However, we show that dynamical heterogeneities play a crucial role which indicates that there are correlations between rearrangements.

11:45 - 12:00 Closing remarks

Posters

Marco Biroli (LPTMS, Paris-Saclay) - Exact order, gap and counting statistics of a Brownian gas correlated by resetting

We study a one-dimensional gas of N Brownian particles that diffuse independently, but are simultaneously reset to the origin at a constant rate r. The system approaches a non-equilibrium stationary state (NESS) with long-range interactions induced by the simultaneous resetting. Despite the presence of strong correlations, we show that several observables can be computed exactly, which include the global average density, the distribution of the position of the rightmost particle, the spacing distribution between two successive particles and the full counting statistics, i.e., the distribution of the number of particles in a given interval. Our analytical results are confirmed by numerical simulations. We also discuss a possible experimental realisation of this resetting gas using optical traps.

Guillaume Palumbo (Université de Mons) - Phase separation and diffusion in binary mixtures of particles with two temperatures

Out-of-equilibrium mixtures of particles in which is maintained a diffusivity (or temperature) contrast have been investigated for a few years now, notably because it constitutes a minimal approach to active matter. Under the right conditions, a phase separation between cold and hot particles appears, with an effective attractive interaction between cold particles, reminding us of the analog phenomenon between active and passive particles in a mixture. On the other hand, it has been shown by Tanaka et. al. that purely repulsive particles attract in a bath of colder particles. In our work, we've been investigating the conditions and the dynamics of the phase separation and the diffusion dynamics and correlations of cold tracers in a bath of hot particles.

Osvanny Ramos (ILM, Lyon) - Some challenges and open questions in scale-invariant avalanches

By choosing a given avalanche definition we will obtain a particular exponent value. Thus, which is the most appropriate variable to measure in order to define an avalanche size? Getting familiar with exponent values: How far our results are from an earthquake-like scenario, or from a depinning model? Should we compare with a mean field result? How reliable is experimental data and recent real earthquake data? Those are some of the questions and challenges that I will like to introduce for discussion.

Vincent Rossetto (LPMMC, Grenoble) - Random walks of photons

The random walk of photons in scattering media is persistent. This is often considered as a random walk with memory of the direction, therefore as a non-Markov process. But this approach is misleading: Considering the photon's state in the phase space rather than in the position space transforms the persistent random walk into a memoryless process, with the Markov property. Moreover, this slight change of perspective also provides Lorentz covariance for the general solutions.

Bassem Sboui (INSA Lyon | UCBL) - An elastic model of lattice distortions in high entropy alloys.

Solid solution strengthening is a well-known mechanism by which solutes of different sizes create lattice distortions and form obstacles to dislocation motion, therefore increasing the yield stress of the alloy. In particular, high entropy alloys (HEA) take great advantage of this strengthening mechanism. In such concentrated alloys, the interactions between atoms of different sizes lead to ubiquitous lattice distortions, that can be characterized by their mean square atomic displacement (MSAD). This quantity has been found to correlate well with the yield stress of the alloy [1]. In addition, it can be measured experimentally by XRD [1] and is easily estimated by atomistic calculations The objective of this work is to establish an elastic model able to predict the amplitude of the MSAD and relate this quantity to the strength of the alloy. Such a model can be very useful in high-throughput explorations of new alloys. We first develop an elastic model of the HEA by considering each atom as an Eshelby inclusion embedded in an elastic continuous medium [2]. If a single diagonal eigentrain tensor (i.e. an average misfit volume) is used for each species, the model turns out to be valid only for a limited number of alloys. To widen the applicability of the model, we consider that each atom is characterized by a non-diagonal eigenstrain tensor, the components of which are random variables that depend on the local atomic environment. We propose a method to probe the statistical distributions of these eigenstrains tensors. This improved version compares well with direct atomistic calculations for various systems, such as Fe-Ni-Cr alloys. As a second step, we use this elastic model to derive the shear stress field and use it in a dislocation dynamics model to study the yield stress as a function of the alloy properties [3]. References: [1] NL Okamoto, K. Yuge, K. Tanaka, et al. Atomic displacement in the CrMnFeCoNi high-entropy alloy ? a scaling factor to predict solid solution strengthening. AIP Advances, 6(12) (2016), 125008 [2] P-A Geslin, D. Rodney. Microelasticity model of random alloys. Part I: mean square displacements and stresses. Journal of the Mechanics and Physics of Solids, 153 (2021), 104479. P-A Geslin, A. Rida, and D. Rodney. Microelasticity model of random alloys. Part II: displacement and stress correlations. 153 (2021), 104480. [3] A. Rida, E. Martinez, D. Rodney, P.A. Geslin. Influence of stress correlations on dislocation glide in random alloys. Physical Review Materials, 6 (2022), 033605.