Master 2 internship proposal

Physique et Mécanique des Milieux Hétérogènes

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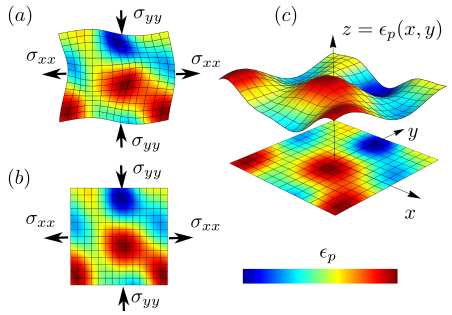
Glass as a flowing solid : memory effects and critical behaviors

Due to their out-of-equilibrium nature, glassy materials keep a memory of their thermal and mechanical past. These two effects are usually discussed independently: the glass structure depends on the rate of the thermal quench from the liquid phase to the glass phase; the plastic behavior of an amorphous material depends on the mechanical loading it has experienced in the past (strain hardening). However more and more recent results suggest a strong coupling between thermal and mechanical effects.
Here we propose to use a minimal model at mesoscopic scale allowing us to account for mechanical and thermal effects in the glassy dynamics. More specifically, we plan to study the behavior of a simple elastoplastic lattice model [1,2] which belong to the larger family of depinning models (generally used to describe the motion of a triple contact line in wetting or a crack front in fracture). Such models are based on the coupling between a stochastic dynamics at local scale and long-range elastic interactions. In the spirit as Ising-like models for magnetism or shell models for turbulence they are easy to implement numerically but rich enough to reproduce the critical behavior (avalanches, finite size effects) and the complex phenomenology of amorphous plasticity (hardening, shear-banding).
Depending on the taste and the interests of the candidate the work may focus on different aspects : glass preparation ; flowing under constant stress at finite temperature (creep) ; fluidization ; polarization under stress ; localization and shear-banding ; effect of elastic disorder ; memory effects...



Analogy between yielding of a n-dimensional object and depinning of a n-dimensional manifold in a space of dim. $n + 1$.

References

[1] B. Tyukodi, S. Patinet, S. Roux and D. Vandembroucq, From depinning to plastic yielding : A soft modes perspective Phys. Rev. E 93 , 063005 (2016)
[2] K. Khirallah, B. Tyukodi, D. Vandembroucq and C.E Maloney, Yielding in an Integer Automaton Model for Amorphous Solids under Cyclic Shear, Phys. Rev. Lett. 126, 218005 (2021)

Expected skills: the applicant has good computing skills and a taste for statistical physics, mechanics and soft matter.