Master 2 internship proposal

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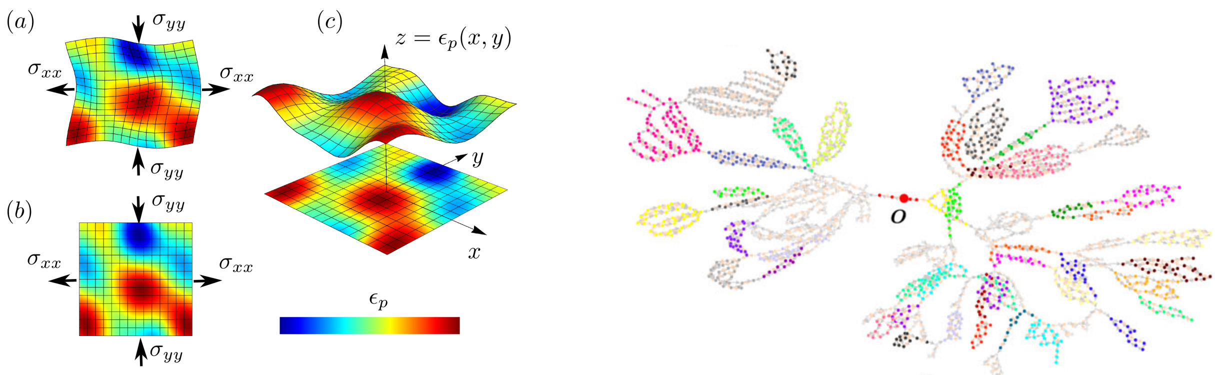
Glass as a flowing solid: memory effects and critical behaviors

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 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. 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 ; transition graph representation of the disordered landscape, etc.



Left: Analogy between yielding of a n-dimensional object and depinning of a n-dimensional manifold in a space of dim. $n+1$ (Color scale gives the level of plastic deformation). Right: transition graph representation of the disordered landscape of a mesocopic elasto-plastic model (Colored regions indicate strongly connected components).

References

[1] D. Kumar, S. Patinet, C.E. Maloney, D. Vandembroucq and M. Mungan,Mapping out the glassy landscape of a mesoscopic elastoplastic model, J. Chem. Phys. **157**, 174504 (2022)
[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: good computing skills and a taste for statistical physics, mechanics and soft matter.