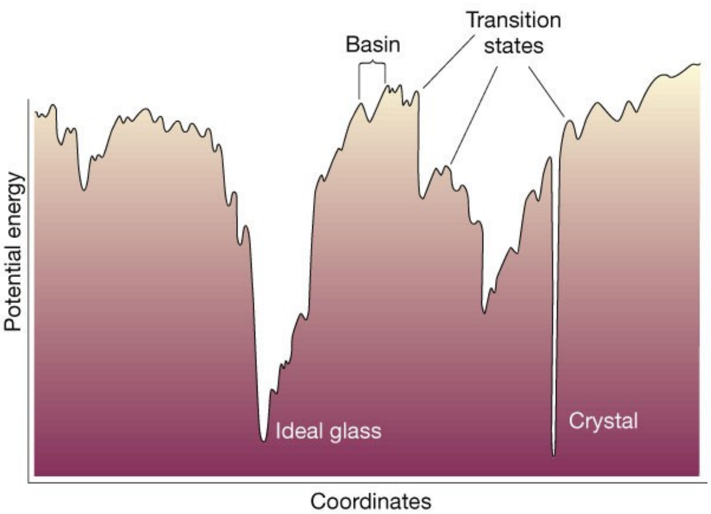
Activated dynamics in the finite-size *p*-spin glass

When a liquid is slowly cooled down under its crystallization temperature, a first-order liquid-solid phase transition occurs, and the system becomes a crystal.
If the cooling is hastened, the particles soon loose energy, and the rearrangement is slowed down. With a quick enough lowering of the temperature T, the time required for the relaxation becomes so large that the system falls out of equilibrium, and the crystalline configuration is never reached in experimental time scales. A system prepared this way is called a glass. The relaxation time in a glass is so high, that by practical means it can be treated as an amorphous solid. The reason of this slowing down in the dynamics is yet not well understood.



Simplified mean field models have been proposed, showing that, at least in the limit of infinite spatial dimensions d, a phase transition occurs. A model that benefitted of great popularity in the description of the glass transition is the p-spin model, a fully-connected Ising spin glass where each interaction couples p spins simultaneously. In the limit of $p \to \infty$, the p-spin model has the same thermodynamics as the Random Energy Model (REM), that describes a system in which each configuration's energy is completely independent from the others. The REM has the advantage of being exactly solvable.
At not too low temperature, the p-spin model behaves qualitatively similar to real glasses. Its limitation is that, being a mean-field model, the free-energy barriers between metastable states are extensive. As a consequence, only diffusive (not activated) dynamics is possible throughout the phase space.
At high temperature this is not an issue, but as T is lowered diffusion is suppressed and the relaxation time diverges. This is not what happens in low dimensions, since the energy barriers are not infinite and can be overcome through activation, so the picture given by the p-spin model is not complete.
In this internship, we propose to study the p-spin model dynamics beyond mean field. This is done by taking large but finite systems. In this way, barriers can be overcome in exponentially long times, and activation takes place. Recently, this type of study has been carried out in the REM, giving new insight on its movement through phase space. Yet, when studied for finite system size N, the limit $p \to \infty$ cannot be taken, so in this approach the REM and p-spin model are expected to behave differently.

The work will consist in trying to understand activation mainly through numerical simulations, focusing on the equilibrium and on the aging regime of the finite-size p-spin model, with $p = N$, and on its relation with the REM.

The internship will be co-directed by G. Biroli (permanent researcher) and M. Baity Jesi (postdoc) at IPhT. The intern will be involved in all Parisian events and activities of the Simons collaboration “Cracking the Glass Problem”.

Contacts:
giulio.biroli@cea.fr
marco.baity-jesi@cea.fr