Bringing together two paradigms of non-equilibrium: Driven dynamics of aging systems

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Non-equilibrium behaviour can be broadly split into two categories. The first is aging (see e.g. [1]), where a system can in principle reach an equilibrium state but its slow dynamics leads to extremely long transients during which the properties of the system depend on its age since preparation. In the second category are driven systems, whose dynamics breaks detailed balance leading to non-equilibrium steady states. An attractive way of constructing descriptions of such driven systems is based on maximum entropy arguments in trajectory space, leading to so-called biased trajectory ensembles (see e.g. [2]).

We investigate how these two non-equilibrium scenarios interact, by studying the bias-driven dynamics of two simple models that are inspired by the physics of glasses and exhibit aging at low temperatures. The analysis allows one to reveal dynamical phase transitions, which are related to unexpected qualitative differences in the robustness of aging to additional driving.

Specifically, we investigate how the interplay between aging and driving by trajectory biasing works in two mean field models of glassy dynamics, widely known as trap models [3,4]. We show that similarly to kinetically constrained models, the equilibrium state of the unbiased system above the glass transition temperature is located at the coexistence of two dynamical phases (active and inactive). In contrast, below this temperature, we find two different nonequilibrium scenarios: energetic (or activated) aging that is destroyed by any dynamical bias towards low activity, which we call "fragile aging", with the system freezing after a finite number of state transitions; and entropic aging that is stable against the existence of such a dynamical bias, which we refer to as "robust aging". We conjecture that these categories have broader relevance as universality classes for aging dynamics in glassy systems.

Time permitting, extensions to dynamics on glassy networks with sparse connectivity will be discussed, where new dynamical phases appear, related to localisation transitions in the leading eigenvectors of the master operators.

References

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