A random polynomial $H$ of degree $p$ on the sphere in dimension $N$: when the coefficients are i.i.d. Gaussian, this is the spherical $p$-spin glass. This Hamiltonian $H$ has exponentially many in $N$ critical points of every index; moreover, its Langevin dynamics at low temperature are known to take exponentially long in $N$ to equilibrate and are believed to exhibit aging on shorter timescales.

We prove an approximate phase diagram for $(H(X_t), |\nabla H(X_t)|^2)$ on order-one time scales. We will discuss consequences of this phase diagram, e.g., uniformly over all starting states, Langevin dynamics at any temperature reaches and remains in a region of macroscopically negative energies, and is repelled by macroscopic neighborhoods of critical points.

This is a Joint work with G. Ben Arous and A. Jagannath.

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