Incomplete equilibrium in long-range interacting systems

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The Hamiltonian Mean Field Model is prototypical in the study of long-range interacting systems. A remarkable feature of its dynamics is the presence, under appropriate initial conditions, of nonequilibrium quasi-stationary states (QSS) whose duration diverges in the thermodynamic limit. These QSSs have been proposed as a benchmark for nonextensive statistical mechanics, since the corresponding distributions in the single particle μ-space can be fitted trough Tsallis' q-exponential functions.

We introduce a Hamiltonian dynamics for the description of long-range interacting systems in contact with a thermal bath (i.e., in the canonical ensemble) and find that QSSs persist in presence of the interaction with this environment. Our results indicate that QSSs are indeed reproducible in real physical experiments.

Despite the presence of an anomalous single-particle velocity distribution, we find that the Central Limit Theorem implies the Boltzmann factor in Gibbs' Γ-space for the QSSs. We precisely identify the nonequilibrium sub-manifold of Γ-space characterizing the anomalous behavior and show that by restricting the Boltzmann-Gibbs approach to this sub-manifold we obtain the statistical mechanics of the QSSs.