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Spontaneous Breaking of U(N) symmetry in invariant Matrix Models

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Matrix Models have a strong history of success in describing a variety of situations, from nuclei spectra to conduction in mesoscopic systems, from strongly interacting systems to various aspects of mathematical physics, from holographic models to supersymmetric theories in the localization limit. Traditionally, the requirement of base invariance has lead to a factorization of the eigenvalue and eigenvector distribution and, in turn, to the conclusion that invariant models describe extended systems.

Moreover, Wigner-Dyson statistics for the eigenvalues is a hallmark of eigenvector delocalization. Thus, in virtually all applications of matrix models, eigenvectors are discarded and one considers just the eigenvalues. We show that deviations of the eigenvalue statistics from the Wigner-Dyson universality reflects itself on the eigenvector distribution and that a gap in the eigenvalue density breaks the U(N) symmetry to a smaller one. Moreover, this spontaneous symmetry breaking means that egeinvectors become localized and that the system looses ergodicity and that the system has lost replica symmetry invariance.

We also consider models with log-normal weight, such as those emerging in Chern-Simons and ABJM theories. Their eigenvalue distribution is intermediate between Wigner-Dyson and Poissonian, which candidates these models for describing a system intermediate between the extended and localized phase. We show that they have a much richer energy landscape than expected, with their partition functions decomposable in a large number of equilibrium configurations, growing exponentially with the matrix rank. We argue that this structure is a reflection of the non-trivial (multi-fractal) eigenvector statistics.

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