Ensemble dependence of the critical behavior of a system with long range interaction and quenched randomness

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A system with long range interaction (LRI) is usually characterized by a non-extensive energy. While, by properly scaling the Hamiltonian of the system, the energy can become extensive, it may still suffer from non-additivity. In other words, such a system with volume V and (rescaled) energy E, cannot be divided into two subsystems with energies E_1, E_2, where $E = E_1 + E_2 + o(V)$. A system is expected to have equivalent thermodynamics within the canonical and the microcanonical ensembles, provided that its energy is additive. Conversely, non-additivity of the energy may result in peculiar microcanonical phenomena (that are not observed in the canonical ensemble) such as negative specific heat or the presence of microstates that are inaccessible to the system, leading to breaking of ergodicity. The Blume-Emery-Griffiths (BEG) model with mean-field-like interaction is a simple example of a model with LRI. We employ that model to propose a mechanism which leads to an inequivalence of the two ensembles, without interfering with the interaction content. To be more specific, we consider a hybrid system governed by the BEG Hamiltonian, where the spins are randomly quenched such that some of them are ``pure'' Ising and the others admit the BEG set of states. It is found, by varying the concentration of the Ising spins while keeping the parameters of the Hamiltonian fixed, that the model displays different canonical and microcanonical phase portraits in concentration-temperature space. Phenomenological indications that these portraits are rich and rather unusual are found.