Replica-symmetry breaking in zero-temperature mean-field spin-glass models

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Spin glasses are frustrated many-body systems where ferromagnetic and antiferromagnetic spin interactions compete. There is a low-temperature ordering in spin-glass models that seems difficult to be described by standard tools of statistical mechanics. The order parameters of the glassy phase are not directly measurable and there are no physical symmetry-breaking fields that would single out the low-temperature order parameters.
Mean-field theory of spin glasses uses the replica trick to introduce order parameters in the glassy phase. Even the simplest model of the Ising spin glass shows a complicated replica-symmetry breaking scheme of Parisi with a continuous order-parameter function in the phase space of replicated spin variables. An explicit solution of the full replica-symmetry scheme is unknown apart from the asymptotic region below the transition temperature to the glassy phase. Even more, arguments have been raised recently about the relevance of the Parisi solution in the zero-temperature limit.[1] We use an explicit representation of the Parisi free energy functional[2] and perform an appropriate low-temperature scaling of its dynamical variables so that we end up with a zero-temperature total-energy functional with full continuous replica-symmetry breaking describing the ground state of mean-field spin-glass models.

[1] A. Crisanti and C. De Dominicis, e-print arXiv:1101.5233 (2011).
[2] V. Janiš, Phys. Rev. B **77**, 101417 (2008).