

Spin glass phase of Edwards Anderson 3D at very low temperatures and largest-ever-seen sizes

Claudio Chilin^{1,2}, Enzo Marinari^{2,3}, Víctor Martin-Mayor¹, Giorgio Parisi^{4,2,3}, Juan J. Ruiz Lorenzo^{5,6}, David Yllanes^{7,8,9}

¹Departamento de Física Teórica, Universidad Complutense De Madrid, Madrid, Spain, ²Dipartimento di Fisica, Sapienza Università di Roma, Rome, Italy, ³CNR-Nanotec, Rome Unit, and INFN, Sezione di Roma, Rome, Italy, ⁴International Research Center of Complexity Sciences, Hangzhou International Innovation Institute, Beihang University, Beijing, China, ⁵Departamento de Física, Universidad de Extremadura, Badajoz, Spain, ⁶Instituto de Computación Científica Avanzada (ICCAEx), Universidad de Extremadura, Badajoz, Spain, ⁷Fundación ARAID, Diputación General de Aragón, Zaragoza, Spain, ⁸Instituto de Biocomputación y Física de Sistemas Complejos, Zaragoza, Spain, ⁹Zaragoza Scientific Center for Advanced Modeling (ZCAM), Zaragoza, Spain

The low temperature phase of Spin Glasses [1, 2] is a matter that has been challenging statistical physicists for years [2].

The mean-field solution to the fully-connected Sherrington-Kirkpatrick model made clear the phenomenology of this infinite-dimensional model in an analytic sense, through a theory called Replica Symmetry Breaking (RSB) [3-6]; but when we go to finite dimensions we cannot rely on analytical results anymore. The question is if RSB theory holds for $D=3$ and here we try to answer through numerical results, a matter that poses another kind of challenge in itself - technical, in this case.

In our work, we investigated the low temperature phase of the Edwards-Anderson model on a 3D cubic lattice, by studying the geometry of the low-energy excitations. While most of the investigations on this subject were based on the computation of Ground States before and after some perturbation [7, 8], thanks to a novel, faster algorithm we have been able to collect equilibrium data for systems of never-reached-before size of $L=16$ down to $T=0.2$.

We then find results in good agreement with the RSB picture, which we can possibly explain in the light of this theory. Finite-size-scaling analysis strongly points towards the nontriviality of the overlap distribution in the $q=0$ sector and the validity of overlap equivalence [9], two observations predicted by RSB theory.

We eventually have been able to frame our results in the context of past works, finding also reasonable explanations in the few cases where discrepancies appeared.

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