Quantum superposition states: Spin-glasses and magnetic classification over entanglement

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Spin glasses have been the subject of many studies due to their very interesting microscopic properties. The most important feature that distinguishes spin glasses from other systems is that they contain random disorder and, accordingly, many possible states of the system at the electronic level occur with very close probabilities [1]. This cause many local minima to occur in the free energy. However, since it is almost impossible to choose any of these almost equally probable configurations that is called frustration effect then the system cannot reach to equilibrium at least in laboratory time. We defined that spin-glass quantum superposition states as equiprobable superposition of possible electronic configurations so called cat states. The cat state is defined as a quantum state composed of two diametrically opposed conditions at the same time [2, 3]. By utilizing the Edward-Anderson type spin-glass order parameter [4] and magnetization, we have demonstrated that our superposition states can be classified based on their contribution to distinguishing magnetic order (disorder), such as spin-glass, (anti)ferromagnetic, and paramagnetic phases. Additionally, we have generalized these superposition states based on the system size. Then we focused on the entanglement of these phase-based superposition states using the negativity [5] measure. We have shown that the spin glass order parameter can be utilized to determine the entanglement of magnetically ordered (disordered) phases, or vice versa, with negativity signifying magnetic order. In conclusion, quantum superposition states are the great interest of quantum computation and quantum information [3] moreover our findings provide further insight into the nature of quantum superposition states and their relevance to quantum spin-glasses and quantum ordered and disordered phases.

References

[1] M. Mezard, G. Parisi, M. Virasoro, Spin Glass Theory and Beyond, World Scientific, 2nd Ed., 1986.
[2] P.T. Cochrane, G.J. Milburn, W.J. Munro, Macroscopically distinct quantum-superposition states as a bosonic code for amplitude damping, Phys. Rev. A. 59 (4), 2631 (1998).
[3] M.A. Nielsen, I.L. Chuang, Quantum Computation and Quantum Information. 10Th anniversary ed., Cambridge, Cambridge University Press, 2010.
[4] S.F. Edwards, P. W. Anderson., J. Phys. F: Met. Phys. 5, 965 (1975).
[5] G. Vidal, R.F. Werner, Computable measure of entanglement, Phys. Rev. A 65, 3, (2002).