SUSY Method for Detection of Energy Levels on a Quantum Computer

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Although supersymmetry (SUSY) is not discovered on the experimental levels, it plays an important role in low-energy physics. In particular, in quantum mechanics, SUSY algebra is responsible for the exact solutions of the Schrodinger equation. There was found a relation between entangled states and the SUSY structure of quantum mechanics [1]. Recently, it was also recognized that SUSY of spin system gives a possibility to formulate a method for calculation of energy levels of the spin system on a quantum computer. The method is based on studies of the evolution of the mean value of operator anticommuting with Hamiltonian. The evolution of the mean value of the anticommuting operator is related to the energy levels of the system which is in contrast to the general case in which the time dependence of some mean value is related to the transition energies of a quantum system. This fact allows us to formulate the method for detecting energy levels on a quantum computer [2]. It is interesting to note that the structure of the energy spectrum in this case is related to the SUSY properties of the system. What is more, this method is restricted to the Hamiltonians for which anticommuting operators exist. The energy spectrum in this case is symmetric with respect to the inversion of the energy. We generalize this method to the case of an arbitrary spin system by adding to the system one probe (ancilla) spin [3] that converts a spin system to a spin one with a SUSY structure. Studies of probe spin evolution allow us to determine the energy levels of the system. The energy levels of various spin systems are found on IBM's quantum computer. The results of quantum calculations are in good agreement with the theoretical ones.

References

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