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The Hubbard model on a square lattice extended global $SO(3) \otimes SO(3) \otimes U(1)$ symmetry: Some preliminary physical applications

A trivial result is that at onsite repulsion $U = 0$ the global symmetry of the half-filled Hubbard model on a bipartite lattice is $O(4) = SO(4) \otimes Z_2$. Here the factor Z_2 refers to the particle-hole transformation on a single spin under which the model Hamiltonian is not invariant for $U \neq 0$. C. N. Yang and S. C. Zhang considered the most natural possibility that the $SO(4)$ symmetry inherited from the $U = 0$ Hamiltonian $O(4) = SO(4) \otimes Z_2$ symmetry was the model global symmetry for $U > 0$ [1]. Although that for $U > 0$ the model contains an exact $SO(4)$ symmetry is an exact result, a recent study of the problem by the author and collaborators [2] revealed an additional exact hidden global $U(1)$ symmetry emerging for $U \neq 0$, such that the model global symmetry is $[SO(4) \otimes U(1)]/Z_2 = SO(3) \otimes SO(3) \otimes U(1) = [SU(2) \otimes SU(2) \otimes U(1)]/Z_2^2$. The extra hidden global $U(1)$ symmetry is related to the $U \neq 0$ local $SU(2) \otimes SU(2) \otimes U(1)$ gauge symmetry of the Hubbard model on a bipartite lattice with transfer integral $t = 0$ [3]. Such a local $SU(2) \otimes SU(2) \otimes U(1)$ gauge symmetry becomes for finite U and t a group of permissible unitary transformations. Rather than the ordinary $U(1)$ gauge subgroup of electromagnetism, for finite U/t here $U(1)$ refers to a "nonlinear" transformation [3]. Since the chemical-potential and magnetic-field operator terms commute with the Hamiltonian, for all densities its energy eigenstates refer to representations of the new found global $SO(3) \otimes SO(3) \otimes U(1) = [SO(4) \otimes U(1)]/Z_2$ symmetry, which is expected to have important physical consequences.
In addition to introducing the new-found extended global symmetry and shortly discussing its consistency with the exact Bethe-ansatz solution of the bipartite one-dimensional model, in this talk some preliminary physical consequences are reported for the Hubbard model on the bipartite square lattice [4,5].

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