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Entanglement in Fermionic Systems

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The characterization of entanglement is a fundamental issue for Quantum Information Theory. But the definition of entanglement depends on the notion of locality, and thus on the tensor product structure of the state space of the composite system. This notion is affected by the presence of superselection rules that restrict the accessible Hilbert space to a direct sum of subspaces.

Indistinguishability of particles imposes one such restriction, namely to totally symmetric or totally antisymmetric states. The entanglement can in this case be defined with respect to partitions of modes in the second quantization formalism. For fermionic systems the Fock space of m modes is isomorphic to the space of m qubits, but the action of creation and annihilation operators is not local, due to their anticommutation.

Conservation of the parity of fermion number imposes another relevant superselection rule. It requires that local physical observables commute with the local parity operator.

Taking into account the considerations above, it is possible to define the set of separable states or equivalently the concept of entanglement for fermionic systems in a number of ways. We study such possibilities, the relationship between different sets and their possible characterization.

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