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Graph Theory in Quantum Many-Body Physics

The Hamiltonian for bosonic and fermionic particles hopping on lattices can be interpreted as the adjacency matrix of an undirected and generally weighted graph. The properties of these quantum many-body systems can therefore be analyzed in terms of graph theory. For example, the simple graph for non-interacting distinguishable particles is the Cartesian product of each particle's adjacency matrix; if these particles become indistinguishable, the graph collapses via a graph equitable partition. In the presence of strong interactions between the particles, the graphs are generally decomposable as weak products (i.e. they are the Kronecker products of adjacency matrices). Under various circumstances, these techniques can allow for the efficient calculation of the eigenstates (and therefore the properties) of physically interesting quantum many-body systems.