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From ground-state densities to entangled wave functions: an exploration for the Hubbard model

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The fundamental Hohenberg-Kohn theorem of density-functional theory (DFT) guarantees that, in principle, all information about a many-body system is contained in it ground-state density. Most effort in DFT is thus directed at finding ways to reliably calculate this density and to extract useful information from it. Quantum-information theory (QIT), on the other hand, is little concerned with ground-state densities, focusing instead on wave functions and density matrices, with a view on exploiting entangled states in information processing. In spite of these different philosophies, many connections exist between both approaches. In this talk, I review of how some of these connections have been discovered and quantified in the context of the Hubbard model: (i) DFT calculations for a model Hamiltonian serve to relate the entanglement entropy to phase transitions; (ii) a local-density-type approximation can be used to calculate the entanglement entropy of spatially inhomogeneous systems, such as cold atoms in optical traps and large superlattices, where traditional numerical methods encounter difficulties; (iii) a combination of DFT with Bethe-Ansatz techniques allows one to calculate the values of system-specific parameters in expressions for the block-block entanglement that remain undetermined in scaling approaches; (iv) the construction of suitable metrics shines light on how the Hohenberg-Kohn theorem relates densities and wave functions for different systems.