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Density Functional Theory from Effective Field Theory[1]

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The combination of progress in chiral effective field theory (EFT) for inter-nucleon interactions, the application of renormalization group (RG) techniques to nuclear systems, and advances in many-body computational tools and methods opens the possibility of *constructive* density functional theory (DFT) for nuclei. Effective actions provide a natural framework for the development of EFT/DFT. One approach uses EFT power counting to define an order-by-order inversion of the generating functional in the presence of a source coupled to the density. This leads directly to Kohn-Sham DFT, which is widely used in condensed matter and quantum chemistry applications. Natural extensions lead to functionals of more general densities and the incorporation of pairing, consistent with phenomenological energy functionals for nuclei, which are themselves consistent with chiral EFT power counting. Chiral EFT offers a model-independent starting point, including a systematic approach to many-nucleon forces. The chiral inter-nucleon interactions are constructed with cutoffs in relative momentum much lower than those in conventional potentials, resulting in much softer interactions. If RG techniques are used to lower the cutoff further while preserving observables, Hartree-Fock plus second-order contributions (with three-body forces included) is found to be a good, possibly perturbative, first approximation for nuclear matter. The dominance of Hartree-Fock, in common with Coulomb DFT, raises hope for a quantitative microscopic construction. There are significant challenges to realizing this goal, both conceptual and technical, such as arise in extending DFT to self-bound systems. But the path is reasonably clear and meshes well with on-going efforts to develop, refine, and test phenomenological energy functionals for application across the mass table.

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