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BCS-BEC crossover in strongly interacting Fermi gases

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We discuss our treatment of the BCS-BEC crossover for trapped Fermi atoms, where the mutual interaction can be tuned from weak to strong coupling by means of a Fano-Feshbach resonance. A simple Hamiltonian describing fermions of two different species mutually interacting with a point-contact interaction leads to an accurate description of the systems that currently are the most widely studied experimentally. The resulting many-body problem is then solved by diagrammatic methods. The superfluid phase is described by a single-particle fermionic self-energy, where it is crucial that pairing-fluctuation effects are included on top of the BCS mean-field. The theory reduces to the Popov theory for dilute superfluid fermions in weak coupling and to the Bogoliubov approximation for the composite bosons in strong coupling (where bosonic molecules form as bound-fermion pairs). Excellent agreement is found by comparing our theoretical results with experimental data on cold trapped Fermi atoms as well as with recent QMC simulations, especially in the crossover region about the unitarity limit. Further developments of the theory will be also discussed.