Pairing and superfluidity in ultracold Fermi gases

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The experimental study of interacting Fermi systems is one of the great success stories of quantum simulation. As a paradigmatic model system, two-component Fermi gases in various regimes of attractive interactions explain the phenomenon of superfluidity and guide our intuitive understanding of collective effects in electronic systems. Yet, clean observations of the underlying physics remain challenging in solid-state systems due to their experimental complexity.

Cold atomic gases offer the opportunity to experimentally study the BCS-BEC crossover from weak to strong attractions in a very clean setting: Ultracold Fermi gases can be realized in a variety of geometries and, most significantly, the interaction strength can be tuned using Feshbach resonances. This versatility has enabled the experimental study of fermionic pairing and superfluidity in many circumstances, ranging from first qualitative observations to highly quantitative measurements of transport and excitation spectra.

In these lectures, I will review the physics of ultracold Fermi gases, introduce the cold atom toolbox for their production and observation, and describe some of the key experiments in the field. I will conclude with an overview over experiments done at Heidelberg University pertaining to the fate of fermion pairing in the small particle number limit.