Summary

In the field of ultracold atoms, new experiments devoted to fermions have been started recently. Fermions show features unknown to bosons like the Pauli exclusion principle or the BEC-BCS crossover. They are rewarding in terms of basic science but challenging in experiment as well as in theory. Fermions are in the center of many fundamental questions physicists aiming to answer. From nuclear physics, condensed matter physics to astronomy and high energy physics. Example research lines are high-T_c superconductivity, the phase diagram of the quark-gluon plasma or dense neutron matter. Strongly interacting fermionic few- and many-body systems pose hard problems for theory and experiments are highly welcome. Mixtures of different fermionic species give additional degrees of freedom, new phases are expected to emerge and a multitude of possible configurations, dimensions, lattices and forms of imbalanced systems are thinkable. Current experiments are about to explore these fascinating new possibilities. In our group we set up a new experiment involving the Fermi-Fermi mixture of ^{6}Li and ^{40}K. Other groups recognized the versatility of this mixture as well such that we have now several experiments worldwide working with this mixture. The individual species were already well known but the properties of the mixture were unknown. The first question to answer was about the two-body properties of the mixture. The scattering length and possible resonances needed to be evaluated. We could identify several resonances of the system and with theory input the singlet and triple scattering lengths were found. The resonances are closed-channel dominated which means they are narrow. The next step was to verify that the mixture remains stable and thermalizes in the vicinity of a broad homonuclear ^{6}Li resonance that we intended to use for evaporative cooling. This is a necessity to reach a low enough temperature before we could obtain molecules on two of the found resonances. The 155-G resonance was then identified to be the ideal resonance of our choice and thoroughly characterized. Although the resonance is quite narrow, we improved the stability of our machine such that we could enter the strongly interacting regime of the ^{6}Li-^{40}K mixture by the observation of hydrodynamic expansion. This opens up the possibility of many new experiments on the BEC-BCS crossover of this mixture.