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A Three-Component Degenerate Fermi Gas.

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We have realized a three-component Fermi gas consisting of the three lowest spin states ($|1\rangle$, $|2\rangle$, $|3\rangle$) of the ^{6}Li atom. Interactions in this system are governed by three different scattering lengths (a_{12}, a_{23}, a_{13}) between the three states, which all exhibit broad and overlapping Feshbach resonances. This enables us to tune the interactions of the system to become both strongly repulsive and strongly attractive, making it a generic three-component system. It is therefore ideally suited to study predictions of exotic phases such as color superconductivity that are expected for example inside of neutron stars. It is also possible to tune the scattering lengths to very small values simultaneously, which facilitates the preparation of the mixture: Starting from a degenerate mixture of atoms in states $|1\rangle$ and $|2\rangle$, we simultaneously apply radio frequencies resonant with the $|1\rangle$-$|2\rangle$ and $|2\rangle$-$|3\rangle$ transitions. This causes the three states to be mixed. To obtain an incoherently mixed sample within a few hundred milliseconds we apply a small magnetic field gradient along the weak axis of our trap. In first experiments we studied the collisional stability of our gas with respect to the magnetic field [1]. We observe an intriguing three-body loss resonance that occurs where all two-body scattering lengths are negative and no two-body bound state exists. The mixture is stable where the scattering lengths are relatively small, which is an important prerequisite for the preparation of the gas. The stable gas is also a good starting point for experiments in the strongly interacting regime, where we aim to observe many-body effects. Progress on this effort will be reported.

[1] T.B. Ottenstein et al., Phys. Rev. Lett. 101, 203202.