Hydrodynamic expansion of a strongly interacting Fermi-Fermi mixture

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We observe two distinct phenomena of hydrodynamic behaviour (inversion of aspect ratio and collective flow) in the expansion of an ultracold Fermi-Fermi mixture [1]. Two species, 75,000 ^{6}Li atoms and 20,000 ^{40}K atoms, are confined in a far-detuned optical dipole trap and evaporatively cooled to degeneracy. Magnetic tuning of *s*-wave interactions allows to realize the strongly interacting regime at the 154.7 G inter-species Feshbach resonance. The optical trap is switched off and the radial and axial widths, σ_r and σ_z, are measured for both species in the time-of-flight expansion. By tuning across the Feshbach resonance (Fig. 1a,b) the aspect ratios, $A_i = \sigma_r^i/\sigma_z^i$, undergo an inversion, clearly demonstrating the main feature of hydrodynamic behaviour. Also the volume parameters, $V_i = (\sigma_r^i)^2\sigma_z^i$, reveal striking features (Fig. 1c,d): while V_{Li} is substantially reduced by the interaction at resonance, V_K clearly shows a significant increase. The dispersive dependence of V_{Li} can be interpreted as the interaction being repulsive (attractive) below (above) resonance. The observed shift may be related to the magnetic field dependence of the interaction energy in the strongly interacting regime. We also observe collective flow of two strongly interacting Fermi species resulting from the hydrodynamic drag effect. In the trap center, the Li atoms spatially overlap with the smaller K cloud and form a hydrodynamic core. After release from the trap the Li atoms stick together with the K atoms at the Feshbach resonance, and the core undergoes a slow collective expansion resulting in the bimodal spatial distribution of the Li atoms. Our observations of the anisotropic expansion and collective flow constitute a first major step to explore the intriguing many-body physics of a strongly interacting Fermi-Fermi mixture.

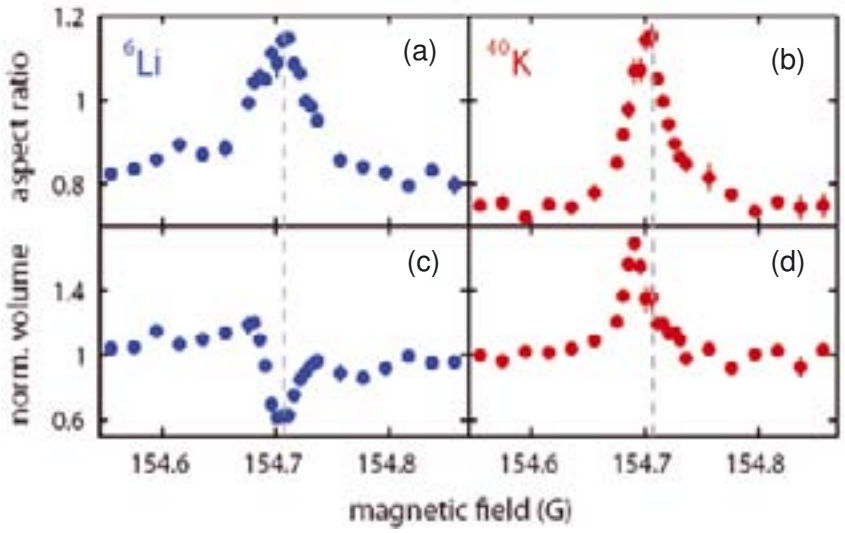

Fig. 1: Magnetic field dependence of the aspect ratios and the volume parameters for ^{6}Li (a,c) and ^{40}K (b,d) observed at the expansion time of 4 ms. The dashed vertical lines indicate the Feshbach resonance.

References

[1] A. Trenkwalder, C. Kohstall, M. Zaccanti, D. Naik, A. I. Sidorov, F. Schreck, and R. Grimm, arXiv: 1011.5192 (2010).