Bragg spectroscopy of a strongly interacting Fermi gas

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Strongly interacting ultracold Fermi gases provide new opportunities for the study of pairing and superfluidity. The ability to precisely tune the interactions between fermions in different spin states using a magnetic field Feshbach resonance has led to the realisation of long lived condensates of paired fermionic atoms in the molecular Bose-Einstein condensate (BEC) to Bardeen-Cooper-Schrieffer (BCS) crossover. We have used Bragg spectroscopy to study this crossover at the broad s-wave Feshbach resonance at 834 G in fermionic ^{6}Li.

Figure 1(a) shows Bragg spectra obtained at various magnetic fields across the Feshbach resonance. These spectra reflect the composition of the gas, being dominated by bosonic molecules below the Feshbach resonance, pairs and free fermionic atoms near unitarity, and free fermions above resonance. Integrating these spectra over the Bragg frequency gives a number proportional to the static structure factor, $S(q)$, where $q \approx 5k_F$ in our experiments (k_F is the Fermi wavevector). In figure 1(b) we plot the integral of the Bragg spectra, normalised so that $S(q) = 2$ in the molecular limit. $S(q)$ decays monotonically from 2 to 1 over the BEC-BCS crossover due to the decay of spin up/spin down correlations [1].

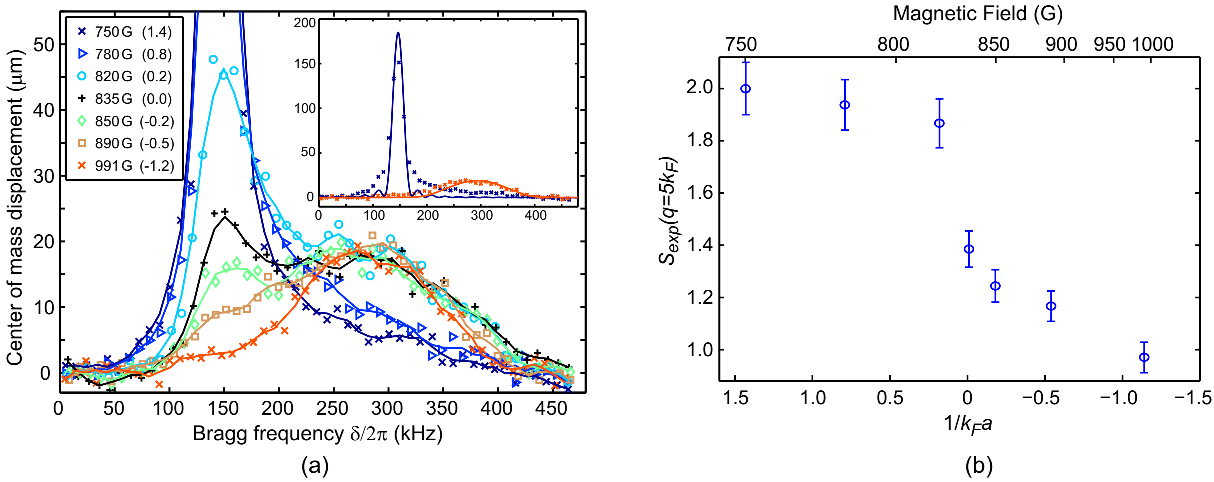

Fig. 1: a) Bragg spectra of a Fermi gas across the BEC-BCS crossover at magnetic fields ($1/k_Fa$) given in the legend. Inset shows the 750 G and 991 G spectra along with the calculated response for an ideal Fermi gas and molecular BEC. (b) Experimental static structure factor $S_{exp}(q = 5k_F)$ vs. the scaled interaction parameter $1/k_Fa$ and magnetic field.

We have also investigated the density dependence of pairing in these gases using Bragg scattering and have been able to distinguish true bound molecules from many-body pairs which occur only in trapped strongly interacting systems [1].

References

[1] G. Veeravalli, E. Kuhnle, P. Dyke, and C. J. Vale, Phys. Rev. Lett **101**, 250403 (2008).