p-wave Feshbach molecules

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Ultracold gases of fermionic atoms near a Feshbach resonance offer an ideal setting to study pairing and superfluidity. The majority of work to date has focussed on gases near s-wave Feshbach resonances in which the interatomic scattering is isotropic. Higher order scattering processes involving nonzero angular momentum are generally suppressed in cold gases as particles do not have the energy to overcome the centrifugal barrier. Near a Feshbach resonance, however, this barrier can be overcome and strong higher order scattering and pairing can occur.

We have studied a gas of ultracold ^{6}Li near the three p-wave Feshbach resonances in a mixture of the states $|F = 1/2, m_F = +1/2\rangle$ ($|1\rangle$) and $|1/2, -1/2\rangle$ ($|2\rangle$). We have produced p-wave molecules and measured their binding energies using radio frequency (rf) magneto-association spectroscopy for all three resonances. The binding energy increases linearly with magnetic field detuning and our measured values of $113 \pm 7\,\mu$K/G, $111 \pm 6\,\mu$K/G and $118 \pm 8\,\mu$K/G for the $|1\rangle$-$|1\rangle$, $|1\rangle$-$|2\rangle$ and $|2\rangle$-$|2\rangle$ resonances, respectively, are in good agreement with theoretical predictions for the magnetic moments of the molecules. Figure 1(a) below shows the binding energy measurements for the $|1\rangle$-$|1\rangle$ resonance with a linear fit (insets show the two other resonances) [1].

In our experiments the lifetime of these molecules was limited to a few ms via inelastic collisions with unpaired atoms. The small size of the molecules and large closed channel fraction, Fig. 1(b), is in stark contrast with typical s-wave molecules and means that the Pauli suppression mechanism responsible for the long lifetimes of s-wave molecules does not apply. It may, however, be possible to extend the molecular lifetime in lower dimensional settings which we are currently investigating.

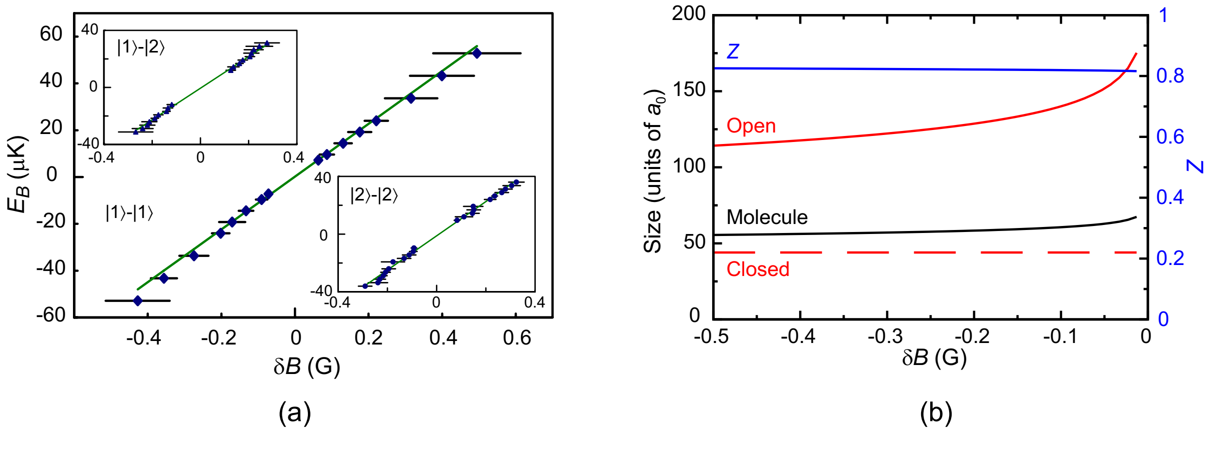

Fig. 1: a) Binding energies of ^{6}Li p-wave Feshbach molecules vs magnetic field detuning. (b) Calculated closed channel fraction (Z), molecule size and size of the open and closed channel components for p-wave molecules below the $|1\rangle$-$|1\rangle$ resonance.

References

[1] J. Fuchs, C. Ticknor, P. Dyke, G. Veeravalli, E. Kuhnle, W. Rowlands, P. Hannaford and C. J. Vale, Phys. Rev. A **77**, 053616 (2008).