

Quantum degenerate mixtures of two or more atomic species open up many exciting avenues of physics research. Such mixtures offer a route to the formation of ultracold ground state heteronuclear molecules as has recently been demonstrated using magneto-association followed by stimulated Raman adiabatic passage (STIRAP)^[1-3]. These molecules have a large permanent electric dipole moment and may provide an alternative approach to quantum information processing^[4]. We present an apparatus designed to study ultracold mixtures of ¹³³Cs and ⁸⁷Rb with the long term goal of creating rovibrational ground state molecules. At present, however, interspecies collisions between ¹³³Cs and ⁸⁷Rb are not well understood and there is insufficient experimental data^[5-7] to constrain theoretical models. To date we have performed Feshbach spectroscopy from 165G to 370G in a baseball magnetic trap for the $F=3, m_F=-3$ and $F=1, m_F=-1$ states of Cs and Rb, respectively and have observed no strong resonances. Here we report our current work to extend this search to magnetic fields in excess of 1000G using the absolute internal ground states confined in an optical dipole trap and outline our plans for future experiments.

Why rubidium and caesium?

Complementary properties

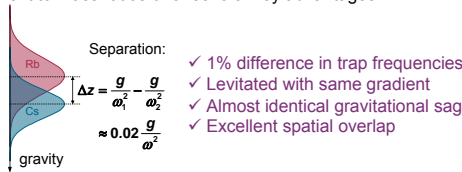
- ⁸⁷Rb is easily condensed due to its favourable collisional properties.
- ¹³³Cs is more difficult to condense, but has a rich Feshbach structure that is highly suited to the production of cold molecular samples of both dimers^[8] and Efimov trimers^[9].

Technical advantages

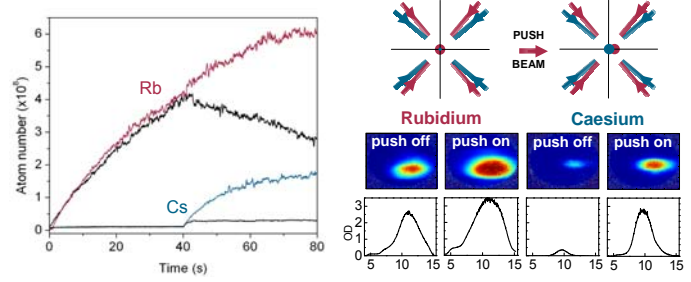
- Near identical magnetic moment to mass ratios offer several key advantages:

For ⁸⁷Rb $|1, \pm 1\rangle$ - Cs $|3, \pm 3\rangle$:

$$\left(\frac{\mu_{Rb}}{m_{Rb}} / \frac{\mu_{Cs}}{m_{Cs}} \right) \approx 1.02$$

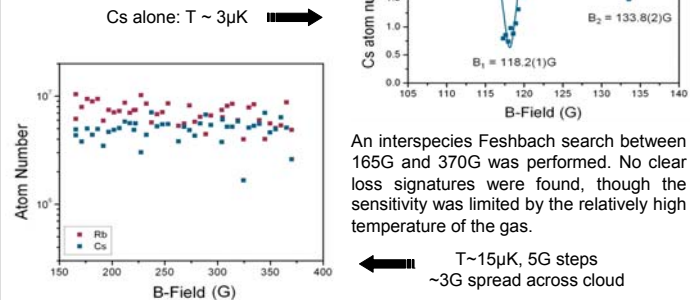


Displaced two-species MOT^[11]



Feshbach Resonances

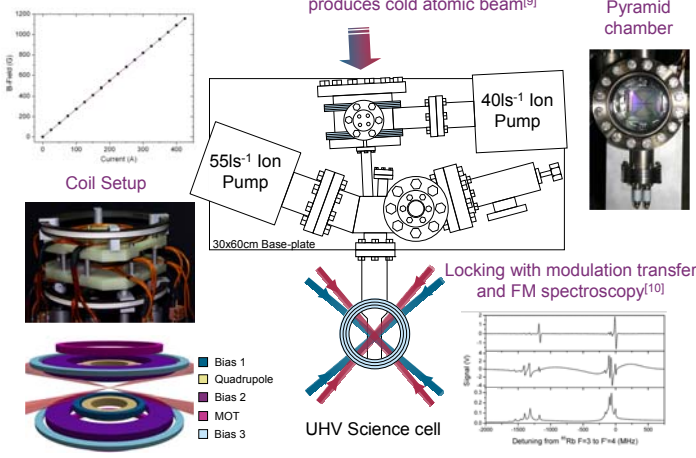
The sensitivity of the apparatus was tested using two well characterised Cs Feshbach resonances.



Experimental setup

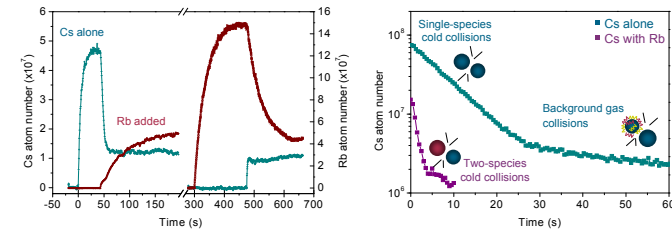
The vacuum apparatus incorporates a two-species pyramid magneto-optical trap (MOT) as a cold atom source for a UHV 6-beam 'science' MOT in a quartz cell.

Maximum Bias Field $\sim 1150G$



Collisions and loss in a two-species MOT^[11]

Interspecies light assisted inelastic collisions can severely limit the loading in a two-species MOT. We find the interspecies collision rates are an order of magnitude higher than the single species rates in line with previous measurements^[12-14].

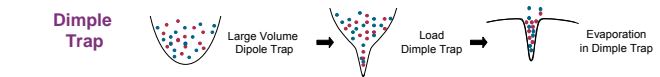


Model and Results:

$$\frac{dN_i}{dt} = L - \gamma N_i - \beta_i \int_V n_i^2 d^3r - \beta_{ij} \int_V n_i n_j d^3r$$

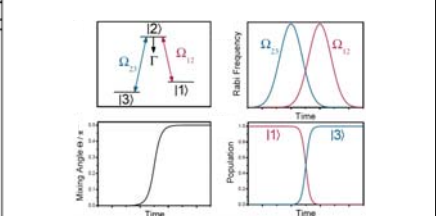
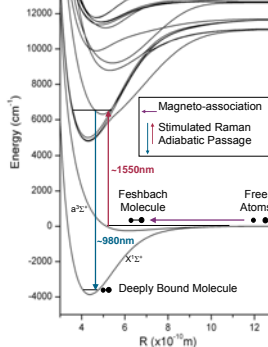
Future work: Optical Trapping

We are currently implementing a crossed beam optical trap generated by a 30W 1.5 μm SF Erbium fibre laser and loaded with a pre-cooled gas from a quadrupole trap. Initial experiments in the optical trap will focus on an interspecies Feshbach resonance search in the ⁸⁷Rb $|1, +1\rangle$ and Cs $|3, +3\rangle$ states up to bias fields of 1000G. Further cooling will be achieved using a dimple potential created by a 2 W Nd:YAG laser.



Stimulated Raman Adiabatic Passage (STIRAP)

The production of deeply bound molecules using the STIRAP process has seen remarkable success^[1-3].



We plan to utilise this approach to produce ultracold polar molecules in the rovibrational ground state from weakly bound RbCs Feshbach molecules. It is predicted that for RbCs this will be possible via a single two-photon transfer step^[15].

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Acknowledgements



This work is funded by EPSRC grants GR/S78339/01, EP/E041604/1 SLC - Royal Society URF