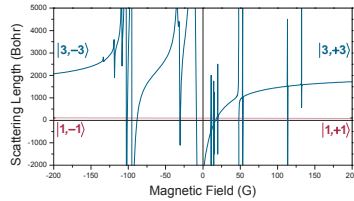


Quantum degenerate mixtures of two or more atomic species open up many exciting avenues of physics research. Such mixtures offer a route to the formation of ultracold ground state heteronuclear molecules as has recently been demonstrated using magneto-association followed by stimulated Raman adiabatic 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. Here we report our current work towards building a combined magnetic quadrupole and red detuned optical dipole trap. Such hybrid traps allow both the efficient capture of atoms from a MOT into the magnetic trap and the rapid evaporation possible in optical dipole traps. Once implemented initial work will focus on a search for interspecies Feshbach resonances in the ⁸⁷Rb |1,+1> and ¹³³Cs |3,+3> states up to bias fields in excess of 1000G.

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].

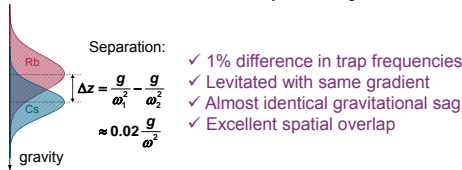


Technical advantages

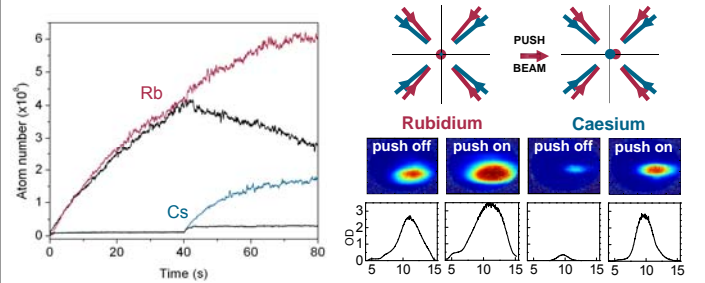
- Near identical magnetic moment to mass ratios offer several key advantages:

For ⁸⁷Rb |1,±1> - Cs |3,±3>:

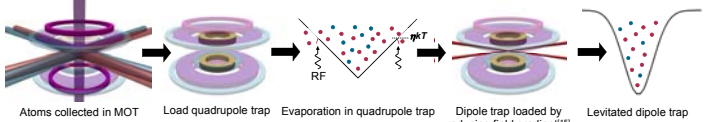
$$\left(\frac{\mu_{Rb}/m_{Rb}}{\mu_{Cs}/m_{Cs}}\right) \approx 1.02$$



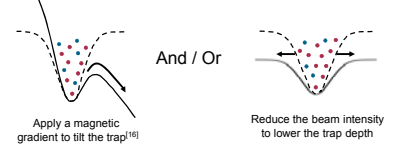
Displaced two-species MOT^[11]



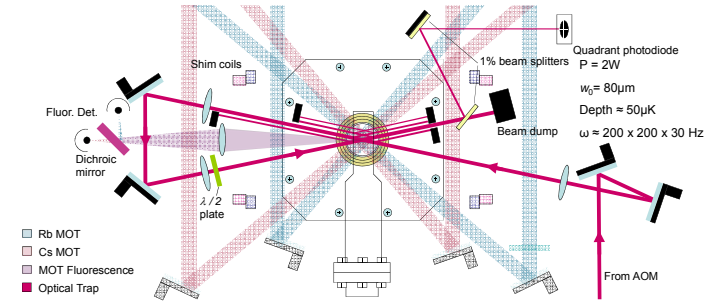
Current work: Magnetic and optical potentials



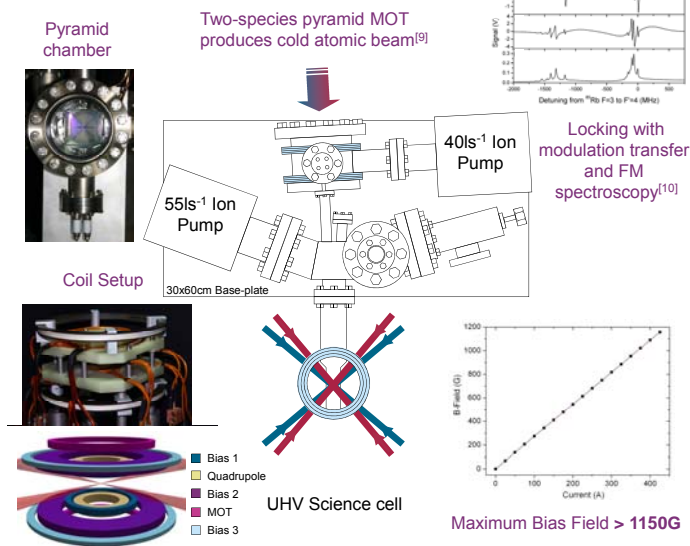
Adiabatic rf transfer will be used to change the spin state once in the dipole trap. Further evaporation will then be performed by reducing the beam intensity and/or by tilting the dipole trap by applying a magnetic gradient.



A 30W 1.5μm SF Erbium fibre laser will produce the crossed beam dipole trap.

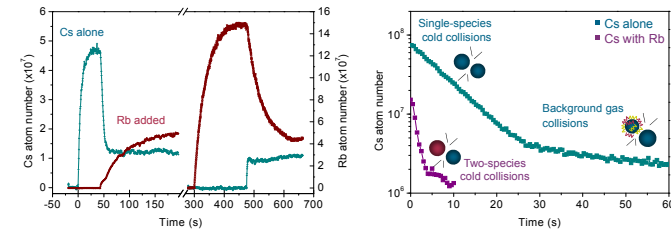


Experimental setup



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].



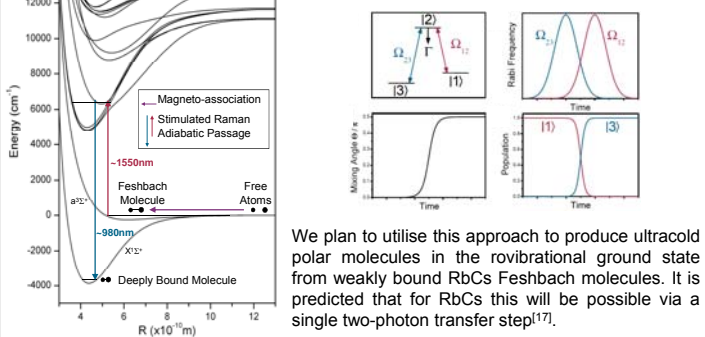
Model and Results:

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

| | |
|----------------|--|
| β_{RbRb} | $2.1(1) \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ |
| β_{CsCs} | $1.5(2) \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ |
| β_{RbCs} | $16(4) \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ |
| β_{CsRb} | $10(6) \times 10^{-11} \text{ cm}^3 \text{ s}^{-1}$ |

Transfer to ground state

The production of deeply bound molecules using the STIRAP process has been 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^[17].

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Acknowledgements

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