Leveraging Yb clock states to form CsYb molecules.

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Alkali – closed-shell molecules are promising candidates for applications in quantum simulation [1] and quantum computing [2], due to the existence of both electric and magnetic dipole moments. Motivated by this, we aim to produce ultracold ground-state CsYb molecules from ultracold mixtures of Cs and Yb atoms using magnetoassociation followed by optical transfer, as is commonly done for bialkali molecules. This combination of atoms presents several advantages for the preparation of the ultracold mixture, including very different atomic polarizabilities and different sensitivities to magnetic fields. Moreover, Cs has a widely tuneable scattering length [3] and the two fermionic and five bosonic isotopes of Yb allow for additional discrete tuning to the interspecies Cs–Yb scattering length. We have previously exploited this control to produce dual-species degenerate mixtures of Cs and Yb [4] and to explore the dynamics of these systems [5].

Producing ultracold molecules through magnetoassociation requires sufficiently strong magnetic Feshbach resonances to allow adiabatic traversal of the avoided crossing between the open and closed channels. In bialkali systems, wide Feshbach resonances arise from electron spin coupling between atoms; however, these couplings do not exist between ground state closed-shell and alkali atoms. Instead, Feshbach resonances arise from additional terms in the collision Hamiltonian involving modifications to the hyperfine coupling [8]. Unfortunately, these weaker effects result in much narrower Feshbach resonances. Nevertheless, interspecies Feshbach resonances have been observed in several alkali atom – closed-shell atom systems, including Rb–Sr [9], Li–Yb [10] and our own work on Cs–Yb [6]. However, magnetoassociation remains very challenging due to the narrowness of the resonances.

Here, we outline plans to leverage the clock states of Yb to overcome this challenge. Recent theoretical work has shown that the magnetic Feshbach resonances between metastable Yb and Cs are stronger than the resonances that occur when both atoms are in their ground states [11, 12]. We plan to exploit this to form CsYb molecules. To enhance the probability of magnetoassociation we will first prepare a dual-species Mott insulator of ground state Cs and Yb. We will then excite Yb to the metastable state, locate and characterise the interspecies resonances, before finally performing magnetoassociation. To accommodate this new approach we have upgraded our apparatus to incorporate a UHV glass cell with nanotextured windows and have designed a novel optical transport scheme that combines the tight axial confinement of an optical lattice conveyor belt [14] with the power efficiency of a translating single beam trap [15]. We will report our progress on implementing this scheme and designs for the new optical trap setup in the UHV glass cell.

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