Introduction

We have trapped ultracold atoms of lithium and ytterbium in a far-detuned optical trap. We will study interspecies interactions, and also prepare diatomic polar Li-Yb molecules.

The Li-Yb system is promising for several reasons:

- Both Li and Yb can be cooled to quantum degeneracy in single-species experiments.
- Stable bosonic and fermionic isotopes are available for both species, allowing for various combinations of fermi and bose gases.
- Species-selective trapping techniques with external magnetic fields are realizable.
- The differences in electronic structure and size of the constituents makes ultracold Li-Yb an ideal candidate for a sensitive electron EDM search.

Theoretical Potential Curves

Preliminary ab-initio calculations of the $X_2\Sigma$ ground and excited potentials. Preliminary ab-initio calculations by Peng Zhang, ITAMP, Harvard

Dual Species Li-Yb Apparatus

For the Li MOT we use a tapered amplifier (Topica Photonics), which produces up to 400 mW at 671nm. We stabilize on the $^6$Li D2 crossover using a heat pipe vapor cell.

For slowing of Yb we utilize the strong 400nm transition $^1S_0 \rightarrow ^1P_1$. We use a 532 nm (Coherent Verdi V-18) pumped Ti-Sa laser (Coherent 899) at 800nm, which is then frequency-doubled in an external bowtie cavity using a LBO crystal to produce up to 100mW of blue light.

For the Yb MOT beams we use the weak 556nm transition $^2S_0 \rightarrow ^2P_1$. We frequency-duplicate the output of a fiber laser (Koheras Bosonik, DW) with a PPLN waveguide (HC Photonics), generating about 20mW of green light.

Crossed-Beam ODT

Initial: $U_0 \sim 4$ mK, $v_{\text{beam}} = 10.8$ kHz $N_1 \sim N_2 \sim 10^6$, $T \sim 200$µK

Reach $T\sim 100$ after 3 s of evaporative cooling.

Fermi Degeneracy in Lithium

We trap an equal mixture of the two lowest hyperfine states of $^6$Li in our optical dipole trap. By increasing the magnetic field to 32G, we achieve a high collision rate with $a_{12} = 50a_0$.

Normalized absorption image of $10^6$ trapped Li atoms, surrounded by the expanding remnants of the MOT. 1.3ms after transfer to ODT.

Dual Species Optical Dipole Trap

For the ODT we use a 100W 1064nm fiber laser (IPG YLR-100-LP). The trap depth is controlled by a single-pass AOM. The trapping beam is focused to a 30µm waist, and our calculated trapping frequencies are 13kHz (7kHz) axially and 85Hz (7Hz) radially for Li (Yb).

The Li MOT is loaded for only a short time (~1s) in the presence of a fully loaded Yb MOT. The two species are then transferred to the ODT. Depending on the Li loading time we can control the relative populations of Li and Yb. After loading into the ODT the initial temperature of either species is ~200µK.

Planned Experiments

Studies in the Li-Yb Mixture

- Thermalization studies between the Li-Yb atoms in an ODT
- Photoassociation and Optical Feshbach Resonances in the Li-Yb
- Yb as an impurity probe of the BEC-BCS crossover in Li
- Strongly interacting Li-Yb mass-mismatched Fermi mixtures

Studies with the LiYb Molecule

- Create ultracold quantum degenerate polar molecular gas using photoassociation followed by Raman processes.
- Explore resulting highly anisotropic interactions both in a homogeneous system and in an optical lattice.
- Measure the electron EDM in this paramagnetic molecule with a high Z-nucleus.
- Candidate for lattice-confined quantum bits interacting via dipole-dipole interactions and as a quantum simulator for lattice-spin models.

Acknowledgements:

E.N. Fortson and B. Blinov groups at UW
J. K. Smith, W. Wilcoxon, R. Weh, W. English, J. Pi, N. Maloney, C. Teale, R. Saxe, J. Grad, E. Lee-Wong
Funding: University of Washington Royalty Research Fund
National Science Foundation
NSERC
Group website: http://phys.washington.edu/users/deepg
Come to our talk: Session W5, Saturday 9am, Astrotum Hall