Building up a modular Na-K quantum gas experiment

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Why quantum mixtures?
- Interaction between fundamental particles is described by gauge theories.
- Implementation: Fermionic species reside on lattice sites, bosonic species (gauge field) on the links

Why Na-K?
- Possibility to work with both K-39 and K-40 (Boseonic and Fermionic) in our design.
- Tuning knob of Feshbach resonances at moderate magnetic fields of less than 300 G [8],
- Predicted to have fast Spin Changing Collisions.

Mobile and modular vacuum system
- K-2D MOT chamber
- Na 2D MOT chamber
- Translation stage

Na laser system
- Laser locking using Zeeman modulation

K laser system
- Master-Slave configuration

Quantum Refrigerator
- Graph Cool thermal cloud below degeneracy threshold
- Implementation: Single K atoms transferred between two baths of Na Atoms

Experimental steps
1. Separated 2D magneto-optical traps
   - Quadrupole magnetic field produced by four stacks of permanent magnets.
   - Two red-detuned circularly polarized laser beams in retro-reflected configuration.

2. Dual-species 3D magneto-optical trap
   - Near-resonant push beam transports pre-cooled atoms into science chamber.
   - Three laser beams in retro-reflected configuration and magnetic quadrupole field.
   - Characterize cold atoms using fluorescence imaging.

3. Crossed Optical Dipole Trap
   - IPG Fiber Laser: 100W at 1070nm.
   - Focused beam waist of 50μm
   - Trap depth: ~2mK.

4. Optical Tweezers
   - TiSa Laser: 2W at 780nm.
   - Focusing through Imaging Objective.
   - Mobile tweezers arrays generated by an AOD

Outlook
- With the achievement of Na and K 3D MOT, we are actively working towards achieving the Na BEC in optical dipole trap and K tweezers.
- We are also implementing an optimized high resolution imaging scheme for the experiment.
- An innovative thermometric technique will be used for non-demolition measurements.
- Techniques for active magnetic field stabilisation (based on NV centres in diamond) are also being developed for tight control over Feshbach fields.
- The experiment control system should facilitate remote access to potentially run the machine 24/7.

References
6. Deep inspired from the group of Manish Endre, California Institute of Technology.