Towards a Non-interacting Coherent Source for Atom Interferometry

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Two-species source of Rb-87 and K (bosonic 39, 41 or fermionic 40)

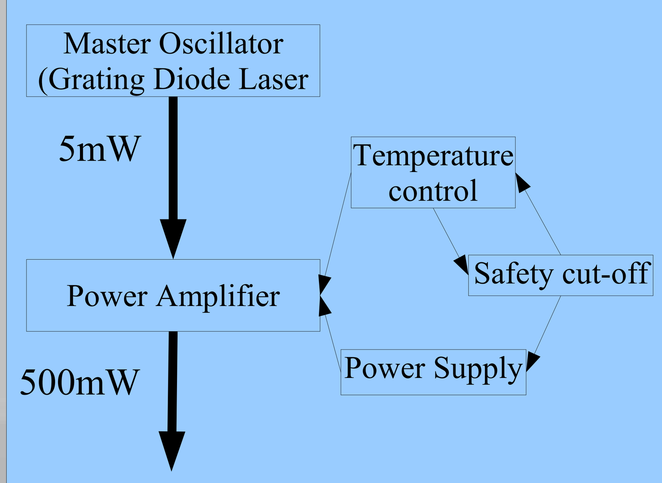
We present plans for the use of a two-species, 2D-MOT as source of collimated, cold, isotopically-enriched, fermionic potassium-40. The 2D-MOT will also be used as a source of bosonic species: rubidium-87 and potassium-39 and -41. The output of the 2D-MOT will feed a 3D-MOT or optical-dipole trap for further evaporative cooling, to produce a mixture of degenerate bosons and degenerate fermions.

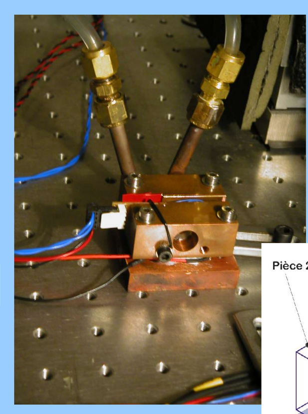
Doubly-degenerate mixtures of K and Rb are to be studied for interspecies interactions, Feshbach resonances, ideal Fermi-gas experiments, and for future interferometric experiments.

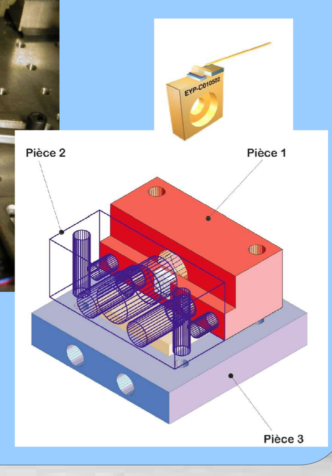
We give some of the technical details of our experimental apparatus.

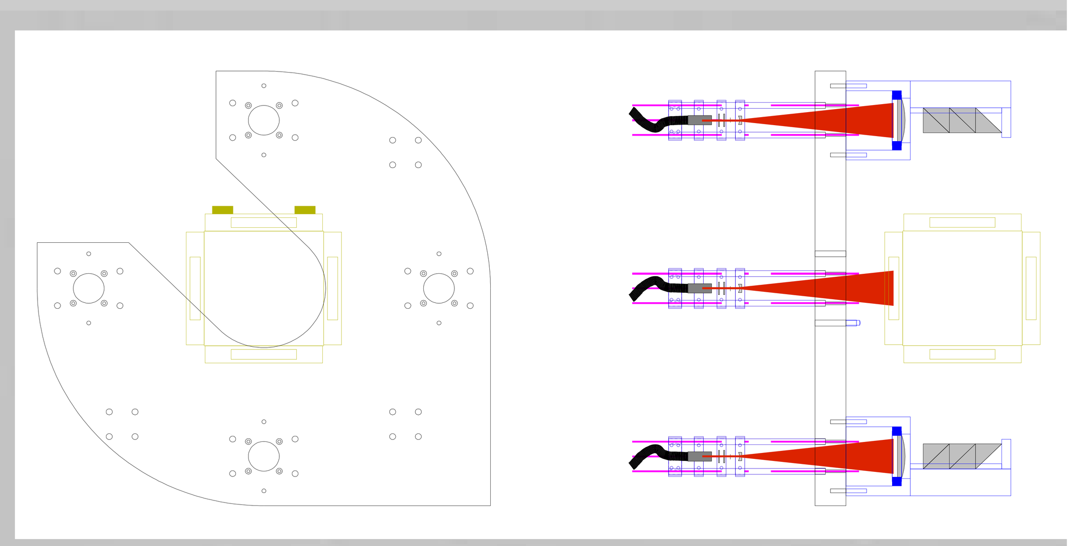
MOPA

We use tapered amplifiers (also from *Eagleyard*). To save money, and have more control, we build the mechanical, electrical and thermal parts ourselves. The whole system is known as MO-PA (Master Oscillator – Power Amplifier).





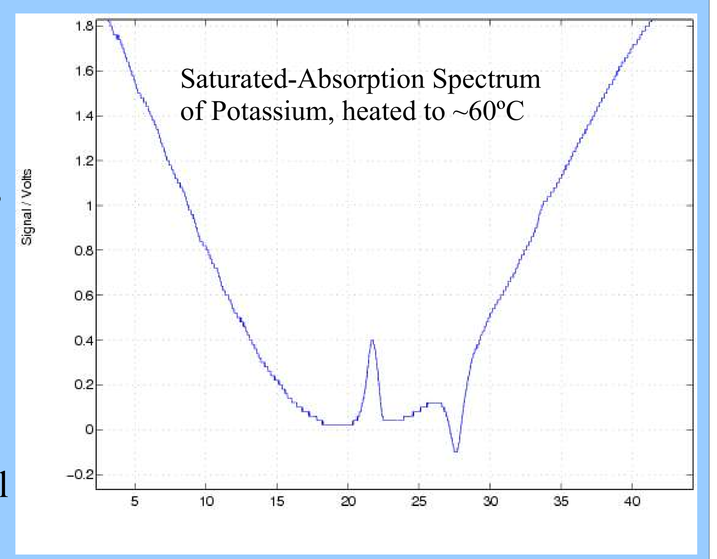




Anti-reflection coated grating-diode lasers

Lasers for rubidium atomic physics (at 780nm) are easy to find and cheap. For potassium (767nm) we use diodes from *Eagleyard*, anti-reflection coated, with wavelength range of 760-790nm.

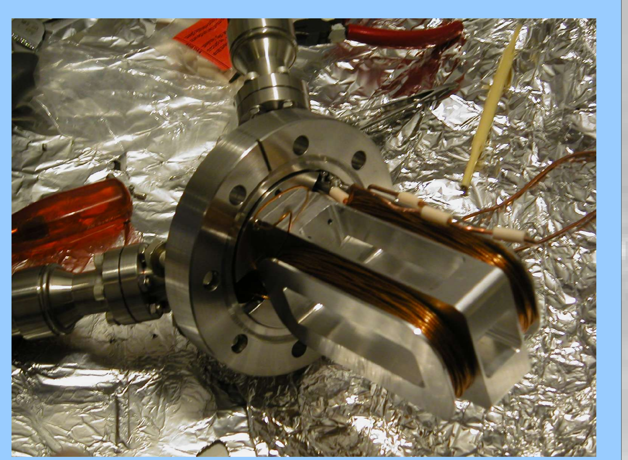
With weak feedback (about 10% diffraction, from *Edmund Optic* holographic grating, intended for use with UV light) we can control the wavelength while remaining efficient (output power >50mW) even at ambient temperature.



2D-MOT as source of Isotopically Enriched K

^{40}K is only 0.012% naturally abundant. Enriched sources are awkward and expensive. We are hoping that the 2D-MOT, in conjunction with a long, thin tube, will act as collimator, cooler and isotopic enricher.

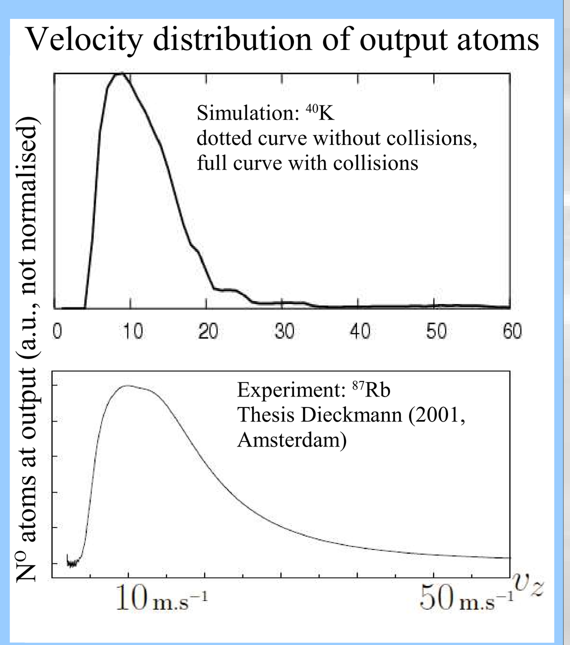
A long, thin output-tube allows for higher pressure in 2D-MOT chamber than "science chamber", and acts as position and momentum selector. The atoms at the output are cooler (smaller spread of momenta) and slower (lower average momentum) than the background gas.



Simulation of 2D-MOT

Simulation: follow the path of ^{40}K atom from dispenser until it either exits or is lost from the trap. Optimise flow of cold ^{40}K atoms at the output

Result: there is an optimum pressure in the 2D-MOT chamber of order 10^{-6} mbar (partial pressure of ^{40}K 10^{-10} mbar). Losses are dominated by collisions with background gas. Magnetic and gravitational forces in the output tube make a big difference to the output flux.



Fixed Optics

We are using a lot of fixed (non-adjustable) optics.

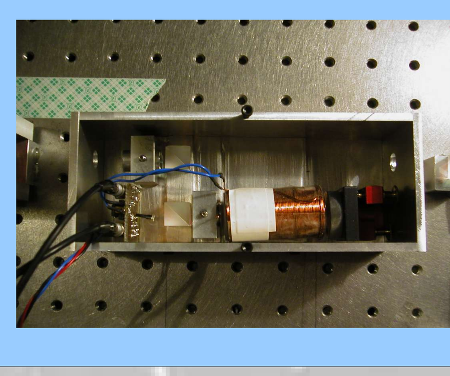
The advantages: If it works, it works.
The experiment can be small

The disadvantages: Pieces must be designed in advance
Difficult to make small adjustments

Optics for 2D-MOT

See background picture

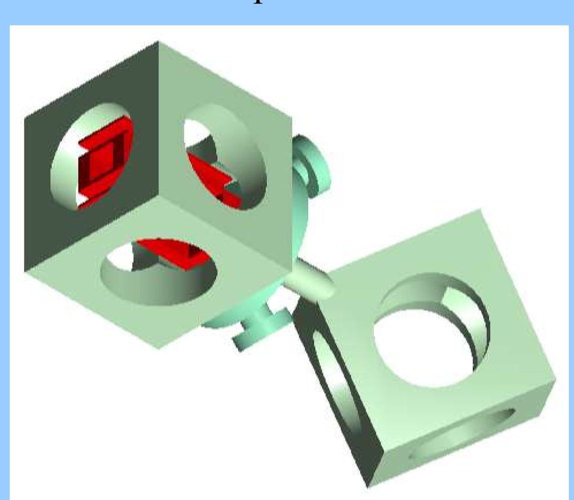
Saturated Absorption Box



Science Chamber

Our two-species source of cold-atoms will supply atoms to a standard 3D-MOT in a "science chamber". These will then be cooled and optically trapped, to make a doubly-degenerate mixture, either condensate-condensate or condensate-Fermi gas. Such a mixture can be used to for experiments in:

- Atom Interferometry
- Tunable Interactions between Rb and K, e.g. Feschbach resonances
- Quantum-fluid dymanics



Zero-Gravity Applications

One of the aims of the project is to develop the technology of cold-atom sources for zero-gravity applications, such as interferometry, gyroscopes, atomic clocks. Theoretically, atomic accelerometers and gyroscopes are more sensitive than their mechanical counterparts. Experiments in zero-gravity permit long times for interrogation of atoms, provided the temperature or the atoms is sufficiently low, i.e ,low enough for quantum-degeneracy.

Tests of General Relativity are also planned in the long term (HYPER mission, `http://atomoptic.iota.u-psud.fr/hyper`)

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