Experiments with the Magneto-Optical Trap

part of the course "nanoprobes, spectroscopy and scattering"

Below is a list of questions. The goal is that by trying to understand the answers to the questions below, you will get more insight into the practical workings of the magneto-optical trap.

Before getting involved with the experiment, please spend about half an hour trying to formulate answers to the questions below (try to make your answers quantitative if possible). Don't hesitate to ask questions is something is unclear. Next, turn to the experiment, and go through the questions again and find the experimental answer. Here, you will certainly want to ask further questions.

- What happens if the laser beams are blocked, and then unblocked again? What are the relevant timescales?
- What happens when the magnetic field gradient is varied in strength?
- What happens if the magnetic field gradient is switched off?
- What happens if one of the MOT coils carries more current than the other coil?
- What happens if the rubidium dispenser (atom source) is switched off (or on)? What are the relevant timescales?
- What happens if a external (homogeneous) magnetic field is added? How sensitive is the MOT to external fields?
- What happens if the detuning (from the atomic resonance) of the laser beams is varied?
- What happens if the laser intensity is varied? What if the beam diameters are varied?
- A typical experimental sequence is to load atoms in the MOT, and then switch to "optical molasses" by switching off the magnetic field gradient, and increasing the laser detuning. What happens if a nonzero magnetic field is still present in the molasses phase?

- A final, more elaborate question: for rubidium, typical temperatures in the MOT and in molasses are 200 μK and 40 μK respectively. If we want to determine this temperature more accurately by using time-of-flight analysis, what are the typical timescales and cloud sizes that we will encounter? In the experiment, make a series of images for various flight times, and use the resulting sizes to determine the cloud temperature.

Additional questions that could turn up during the experiments (concentrate on these *only* if you have time to do so).

- How stable is the laser frequency locked to the atomic line?
- How does an acousto-optic modulator work?
- What happens if we add a magnetic field to the rubidium vapor cell used for laser locking?
- What happens if the repumper laser is blocked? What is the repumper used for anyway?