

Figure 1: MOT luminescence intensity with background as a function of the polarization angle before the first MOT pass-through of one beam.

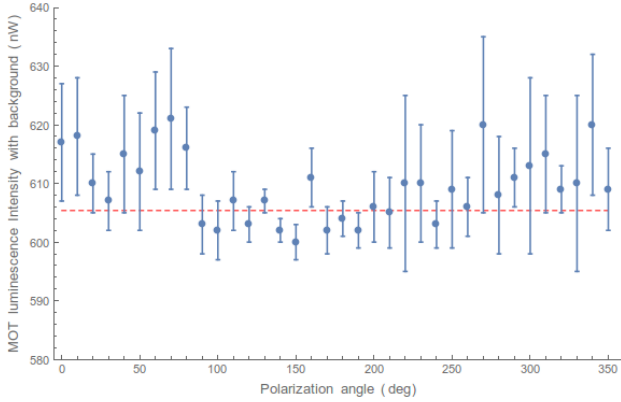


Figure 2: MOT luminescence intensity with background as a function of the polarization angle before the second MOT pass-through of one beam.

1 new things

1.1 Polarization direction dependence

As it is visible on Figure 1, the MOT luminosity changes periodically, following a π periodic dependence; the fitted function

$$f(x) = A \cos\left(\frac{\pi x}{180^\circ} - \varphi\right) + B$$

serves the purpose of confirming the periodicity, as the fitting is otherwise distorted by the abundance of near-maximum points compared to those near the minimum. Figure 2 shows the unadjusted luminosity as a function of the polarization angle of the beam changed before the second passing through the sample. Here, the strong fluctuations make it impossible to notice fine angle-dependent changes. The underlying function is likely a constant function, shown as the red dashed fitted line.

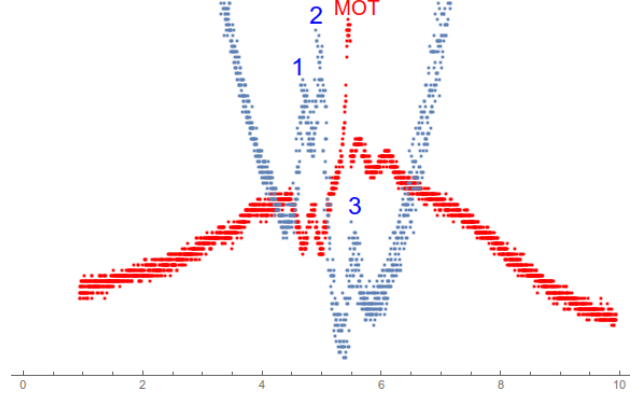


Figure 3: MOT luminescence intensity with background as a function of the polarization angle before the second MOT pass-through of one beam.

1.2 Detuning of the cooling laser

To quantify the ideal detuning of the cooling laser, we used a slow periodic signal to scan through the spectrum slow enough that the changes in the MOT can be recorded on an oscilloscope. The detected peaks ($F \rightarrow F1$ and MOT fluorescence peak):

$$\begin{aligned} 3 \rightarrow 2, 4 : & \quad (4.708 \pm 0.024) \text{ s} \\ 3 \rightarrow 3, 4 : & \quad (4.956 \pm 0.024) \text{ s} \\ 3 \rightarrow 4 : & \quad (5.556 \pm 0.016) \text{ s} \\ MOT : & \quad (5.456 \pm 0.008) \text{ s} \end{aligned}$$

By matching the difference of peaks 1, 2 and peaks 2, 3 with the frequencies of the transitions, averaging the results yields a frequency scale of

$$C = (114.161 \pm 11.163) \frac{\text{MHz}}{\text{s}}$$

The optimal detuning is the difference between the MOT and the $3 \rightarrow 4$ peaks:

$$\Delta\nu = C \cdot (0.100 \pm 0.008) \text{ s} = (11.4161 \pm 1.4423) \text{ MHz} \quad (1)$$

1.3 Detuning of the pumping laser

We found the following peaks:

$$\begin{aligned} 3 \rightarrow 2, 4 : & \quad (4.708 \pm 0.024) \text{ s} \\ 3 \rightarrow 3, 4 : & \quad (4.956 \pm 0.024) \text{ s} \\ 3 \rightarrow 4 : & \quad (5.556 \pm 0.016) \text{ s} \\ MOT : & \quad (5.456 \pm 0.008) \text{ s} \end{aligned}$$

1.4 Population of MOT

$$R = \frac{\Gamma}{2} \frac{\frac{I}{I_{\text{sat}}}}{1 + \frac{I}{I_{\text{sat}}} + \left(\frac{2\Delta\nu}{\Gamma}\right)^2} = (18.4915 \pm 0.0434) \text{ MHz}, \quad (2)$$

where $\Gamma = 2\pi \cdot (6.0666 \pm 0.0018)$ MHz is the natural linewidth of the transition, $I_{\text{sat}} = (1.66932 \pm 0.00035) \frac{\text{mW}}{\text{cm}^2}$, $I = \frac{2P}{\pi w^2} = (73.9409 \pm 3.00633) \frac{\text{mW}}{\text{cm}^2}$ the total cooling laser intensity ($P = 10.60 \pm 0.05$ mW is the total power), and $\Delta\nu$ is the detuning of the cooling laser (eqn. 1).

The total intercepted power at a distance ρ from the MOT by a lens with radius r , when the MOT has a radiation power P_{MOT} , is

$$P = \frac{P_{\text{MOT}}}{4\pi\rho^2} \cdot \pi r^2,$$

from which ($\rho = (10.5 \pm 1.0)$ cm, $2r = (2.5 \pm 0.1)$ cm)

$$P_{\text{MOT}} = 47.4 \pm 9.8 \mu\text{W} \quad (3)$$

References

- ¹ Unspecified Author, *FP Experiment: Rubidium MOT* (University of Bonn, 2014).
- ² D. A. Steck, *Rubidium 85 D Line Data*, <http://steck.us/alkalidata/rubidium85numbers.pdf>