Physics 4062/5062 – Tutorial Six - Discussion of Lab Report

Nature of Lab Report

- Comprehensive
- Open ended
- Creative
- Backed by data
- Structure similar to PHYS 3220, PHYS 4210, PHYS 4211.

Experimental Sections

Each of the experimental sections must include motivation, description, tests, figures, data analysis and discussion

1. Spectroscopy, lock points
2. Laser locking
3. Frequency shifting using AOM
4. Alignment
5. Polarization
6. Coils positioning, wiring
7. Observation of Rb fluorescence in cell
8. Checks on atom trap
9. Cold Atom Experiments

Understand required and optional experiments

Grading Scheme for Lab Report

Abstract, Introduction, Conclusions	10%
Theory	20%
Experiment on Atom Trapping	20%
Investigations with cold atoms	15%
Discussion, Interpretation	15%
Grammar and Citation	10%
Presentation	10%

Part Two – Remarks about Optical Depth and Independent Method for Measuring the Number Density, n

Method One (Previously Discussed)

Combine atom number from trap fluorescence and cloud radius from CCD to measure density.

In a harmonic trap, the density has a Gaussian spatial distribution given by:

$$n(r) = n_o \; exp\left[-2\left(\left(\frac{x}{x_o}\right)^2 + \left(\frac{y}{y_o}\right)^2 + \left(\frac{z}{z_o}\right)^2\right)\right]$$

Here x_o, y_o, and z_o, are $1/e^2$ radii.

The atom number, N can be obtained by integrating n(r) over volume, so that

$$n_o = \frac{N}{x_o y_o z_o}\left(\frac{2}{\pi}\right)^{\frac{3}{2}}$$

Method Two

The density can also be measured directly by scanning a probe laser across the atomic resonance. The atom number can be obtained by combining the density and the cloud size.

Recall Beer's Law

$$I = I_o \; \exp(-\alpha L)$$

I_o is the incident intensity, $\alpha(\omega, x)$ is the frequency dependent absorption coefficient.

For a uniform spatial distribution,

$$\alpha = \alpha(\omega)$$

For trapped atoms with a Gaussian spatial distribution,

$$\alpha(\omega, x) = K \frac{f_{ik} \, \Gamma_{\mathrm{eff}} \, \mathrm{n_o} \, \exp\left(-2\left(\frac{x}{x_o}\right)^2\right)}{((\omega - \omega_o)^2 + \left(\frac{\Gamma_{\mathrm{eff}}}{2}\right)^2}$$

$$K = \frac{q^2}{4\pi\varepsilon_o m_e c}$$

$$f_{ik} = \frac{\varepsilon_o m_e c^3}{2\pi q^2 \upsilon^2} \text{ Oscillator strength}$$

Using the value of α in Beer's Law, it is possible to obtain a fit function the models the Lorentzian absorption profile of trapped atoms. The peak density can be obtained from the fit, and combined with the cloud size along x to find N.