

Optical Pumping

Yichao Yu

MIT

April 3, 2013

Introduction

- Non-equilibrium energy levels population.
- Atom state preparation.
- Laser cooling and trapping.

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Zeeman slower which uses optical pumping and Zeeman effect to slow down a hot atom beam.

- 1 Atom energy levels and optical pumping.
- 2 Apparatus and measurement.
- 3 Data and result.
- 4 Conclusion.

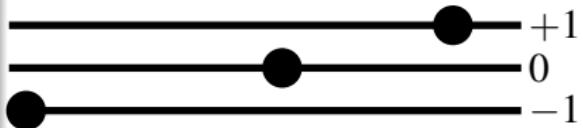
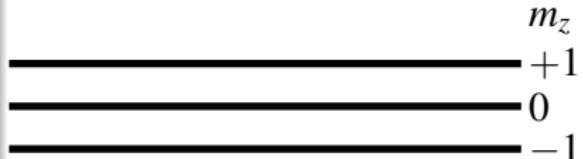
Atom energy levels and optical pumping.

- Fine, hyperfine structure, Zeeman splitting.

$$\frac{n_1}{n_2} \Big|_{\text{fine}} = e^{-\beta \Delta E} \approx 1$$

- Optical pumping in m_z states.
Circular polarization light,
 $\Delta m = +1$.
Spontaneous emission,
 $\Delta m = 0, \pm 1$.
- Dark state.
- Depolarization using RF signal.

$$\Delta \mu B = hf$$



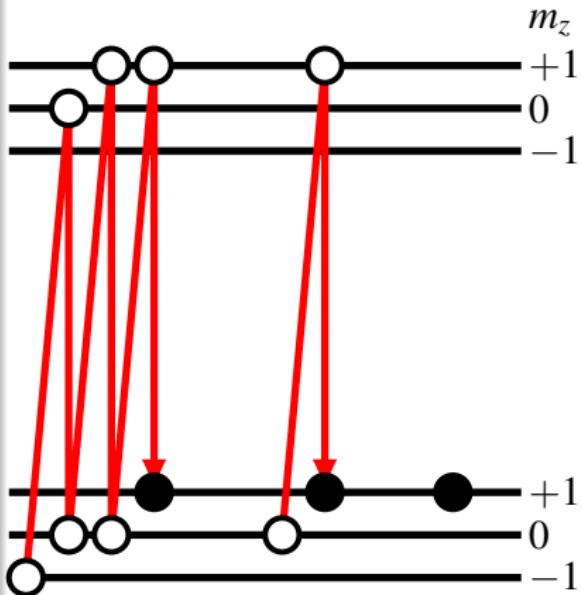
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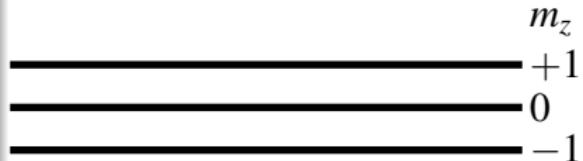
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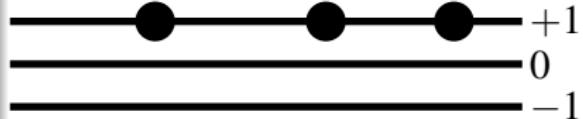
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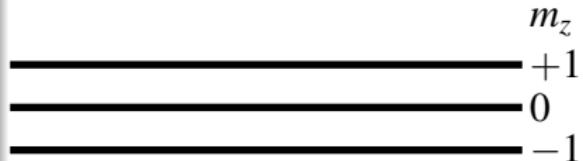
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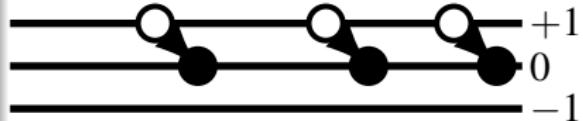
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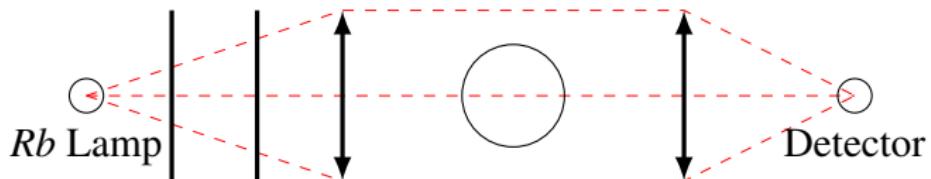


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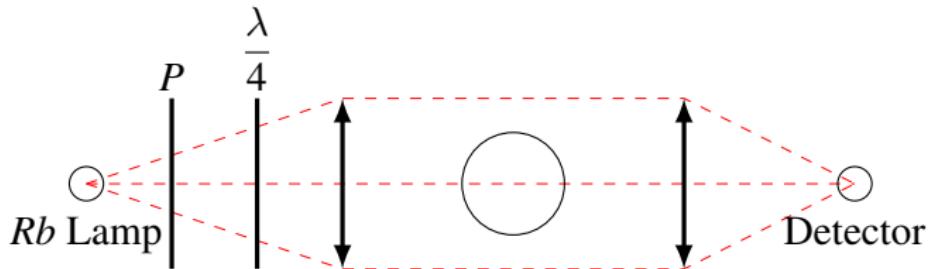


Apparatus.



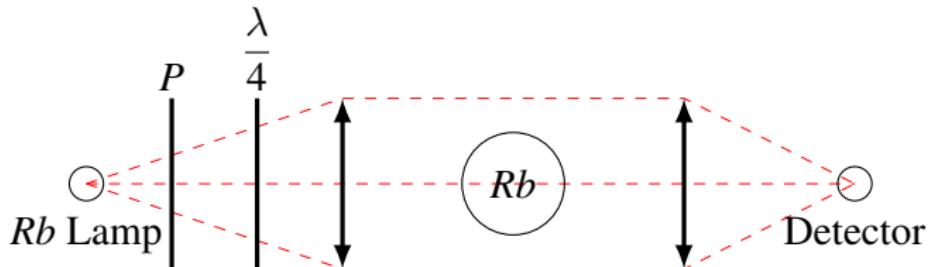
- Circular polarization.
- ^{85}Rb and ^{87}Rb
- B field.
- RF field.

Apparatus.



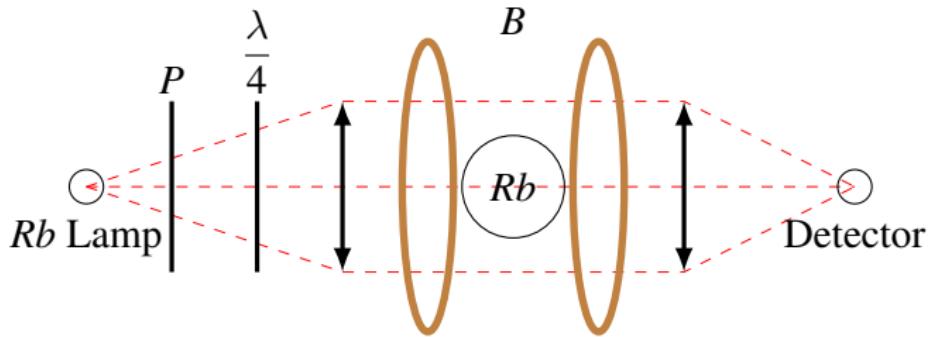
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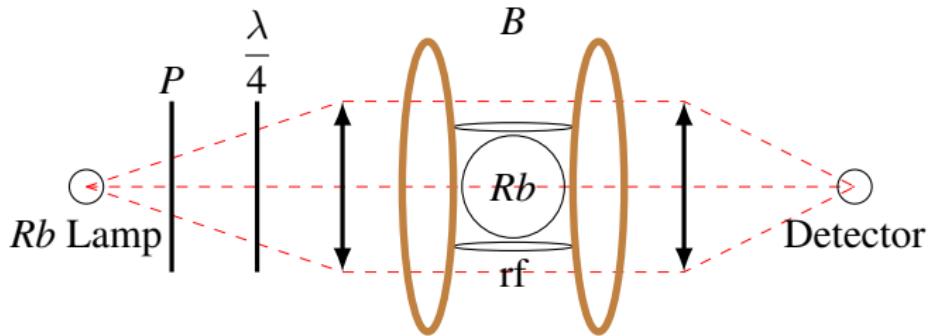
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Measurement

$$\Delta\mu B = hf$$

$$f_{RF} = \frac{g_F \mu_B}{h} \sqrt{(B_x + B_{x0})^2 + (B_y + B_{y0})^2 + (B_z + B_{z0})^2}$$

- Scan RF frequency.
- Scan B field.
- Switch B field.

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Scanning RF frequency at different B field.

- Scan RF frequency.
 - Scan B field.
 - Switch B field.
- Measure/cancel earth magnetic field.
 - Natural Abundance. Different from the strength of the absorption.

$$I_{absorb} \propto NA \cdot g_F^2$$

Measurement

$$\Delta\mu B = hf$$

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- Scan RF frequency.
- Scan B field.
- Switch B field.

Scan B field at different RF frequency.

- Measure resonance frequency.

Measurement

$$\Delta\mu B = hf$$

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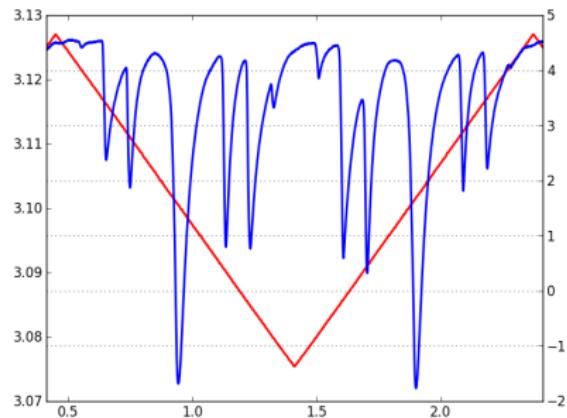
- Scan RF frequency.
- Scan B field.
- Switch B field.

Switch B at different light intensity.

- Measure pumping rate.

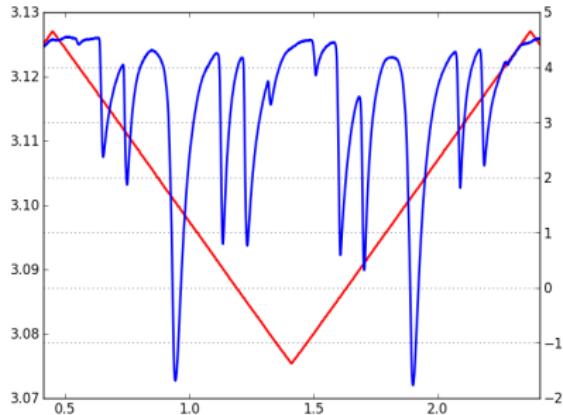
$$R \propto I_{light}$$

Scanning B field.



Light intensity when scanning B field.

Scanning B field.

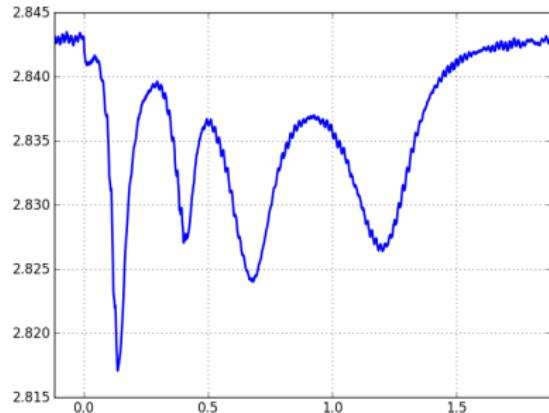


g_F factor.

Isotope	Measured	Expected
^{85}Rb	0.498(19)	0.500
^{87}Rb	0.331(13)	0.333

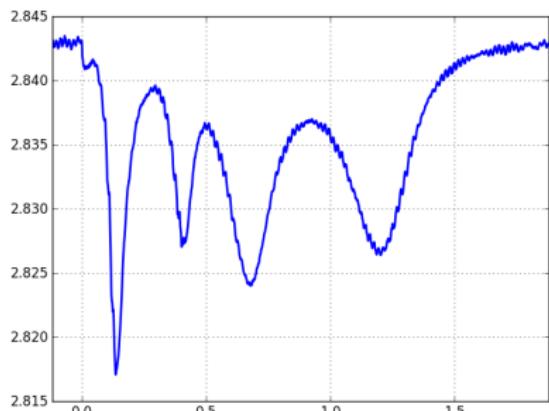
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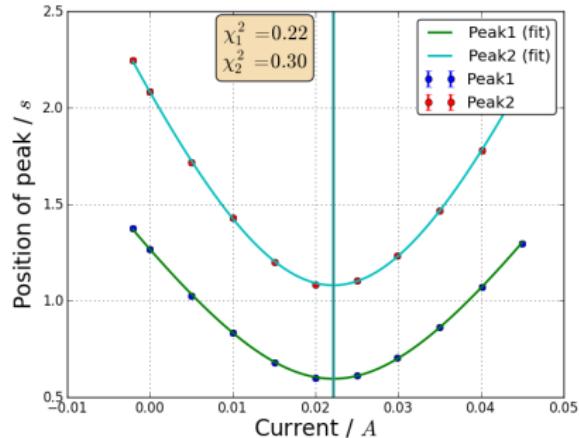


Light intensity when scanning RF frequency.

Scanning RF frequency.



Light intensity when scanning RF frequency.

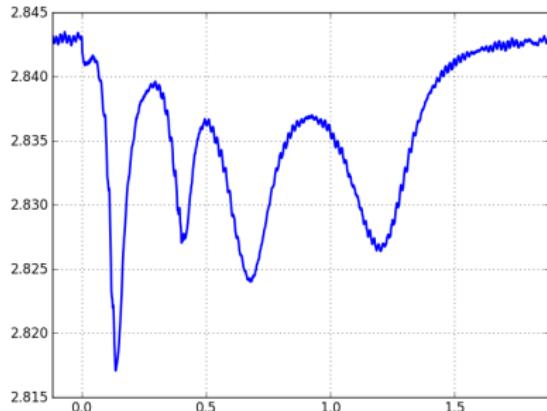


Peak positions at different y current

Ambient magnetic field.

B_x/mGs	361(10)
B_y/mGs	72.2(1.6)
B_z/mGs	191.6(5.2)

Scanning RF frequency.



Natural Abundance.

Isotope	Measured	Expected
^{85}Rb	72.0(2.2)%	72.168%
^{87}Rb	28.0(2.2)%	27.835%

Light intensity when scanning RF frequency.

Conclusion.

- Observed optical pumping and depolarization.
- Ambient magnetic field.
- g_F factors.
- Natural abundance of ^{85}Rb and ^{87}Rb .

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Landé g-factor

$$g_J \approx \frac{3}{2} + \frac{S(S+1) - L(L+1)}{2J(J+1)}$$

$$g_F \approx g_J \frac{F(F+1) - I(I+1) + J(J+1)}{2F(F+1)}$$

$$S = \frac{1}{2} \quad L = 0 \quad J = \frac{1}{2}$$

$$I = \begin{cases} \frac{5}{2} & (^{85}\text{Rb}) \\ \frac{3}{2} & (^{87}\text{Rb}) \end{cases}$$

$$F = \begin{cases} 3 & (^{85}\text{Rb}) \\ 2 & (^{87}\text{Rb}) \end{cases}$$

$$g_F = \begin{cases} \frac{1}{3} & (\text{Rb}^{85}) \\ \frac{1}{2} & (\text{Rb}^{87}) \end{cases}$$