Doppler-free spectroscopy

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Introduction

- Saturated absorption.
- Precise spectrum measurement.
- Frequency stabilization and locking.

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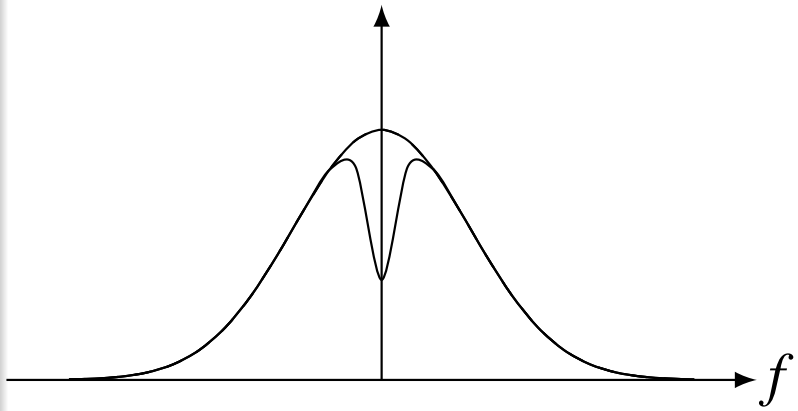
1. Saturated absorption and atom hyperfine structure.
2. Apparatus and measurement.
3. Data and result.
4. Conclusion.

Doppler broadening and spectral hole buning.

- Natural line width.
- Doppler broadening.

$$\Delta f = \frac{v}{c} f_0 \approx 100MHz$$

- Cooling.
- Saturated absorption: whole burning without doppler broadening.



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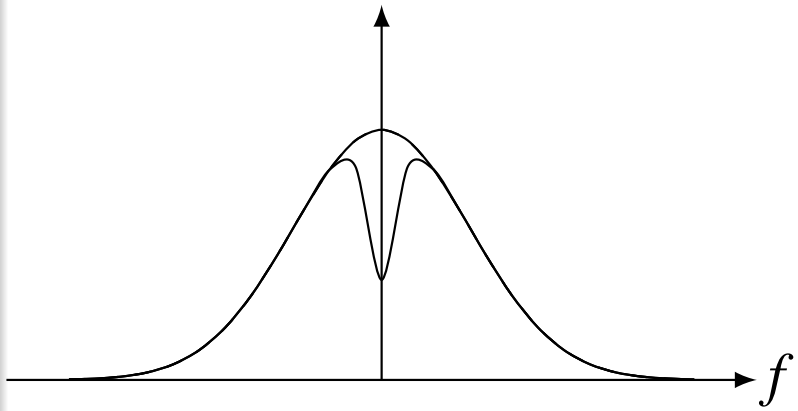

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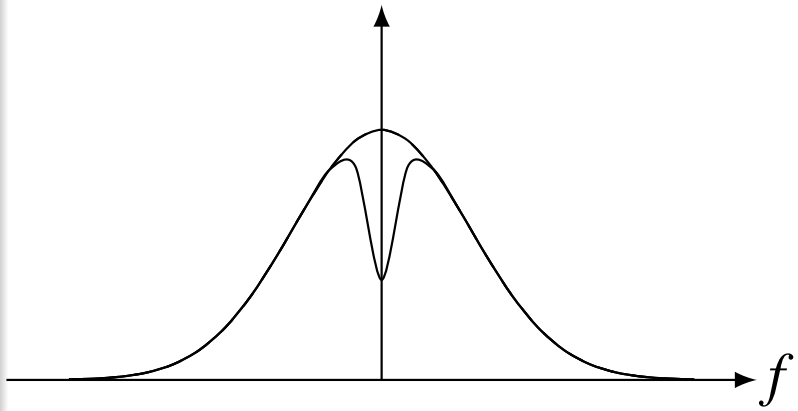

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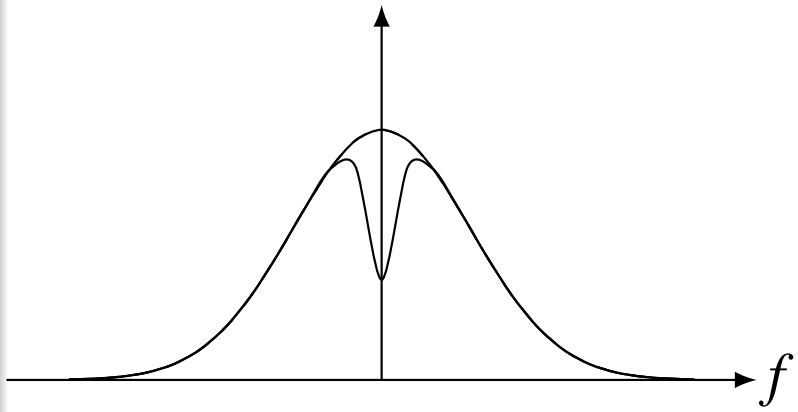

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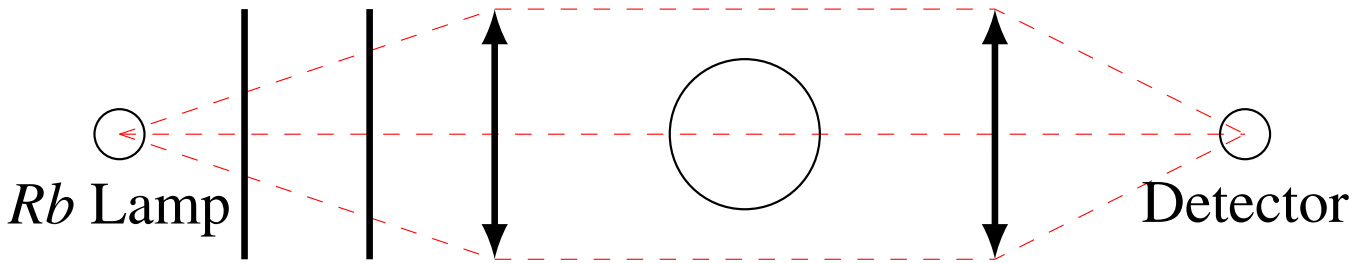

- Circular polarization.
- ^{85}Rb and ^{87}Rb
- B field.
- RF field.

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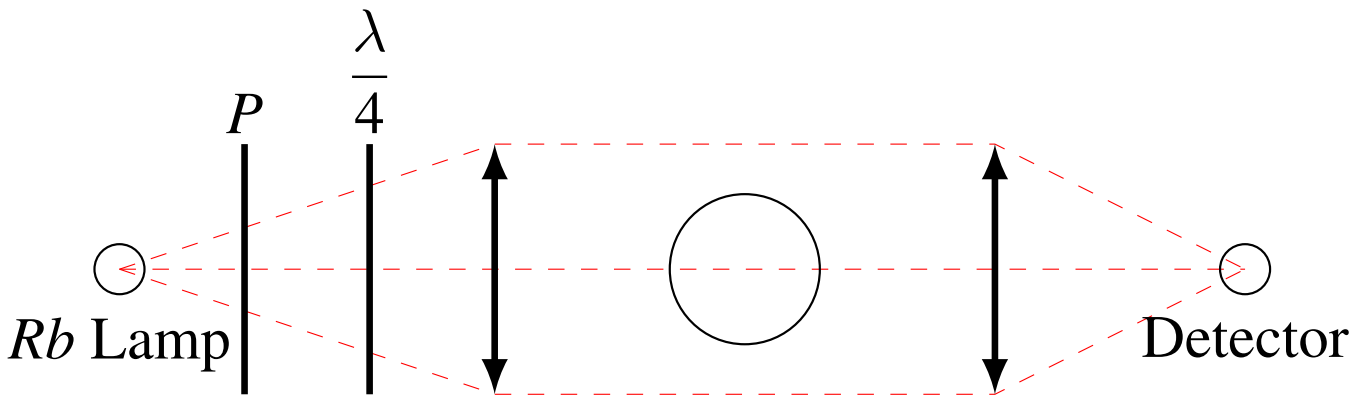

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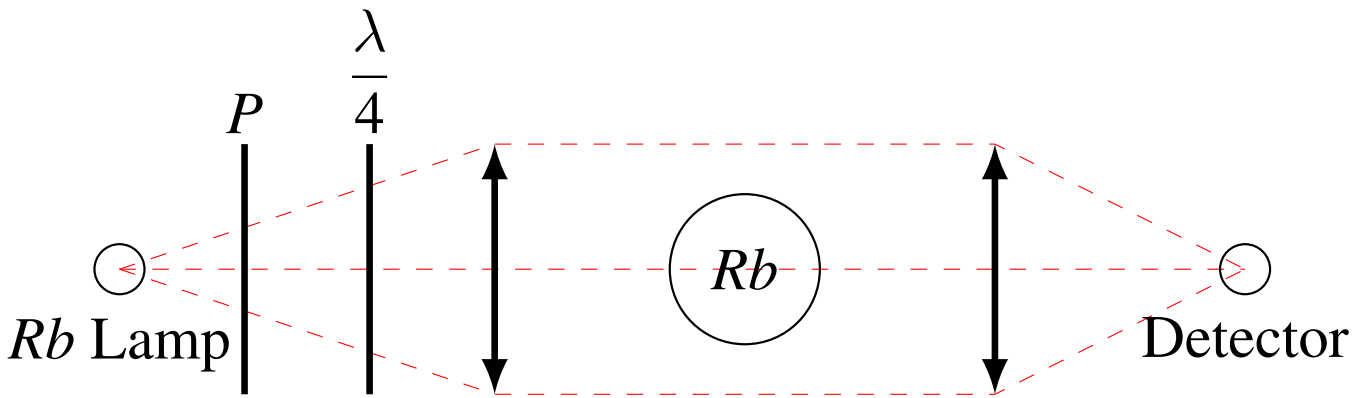

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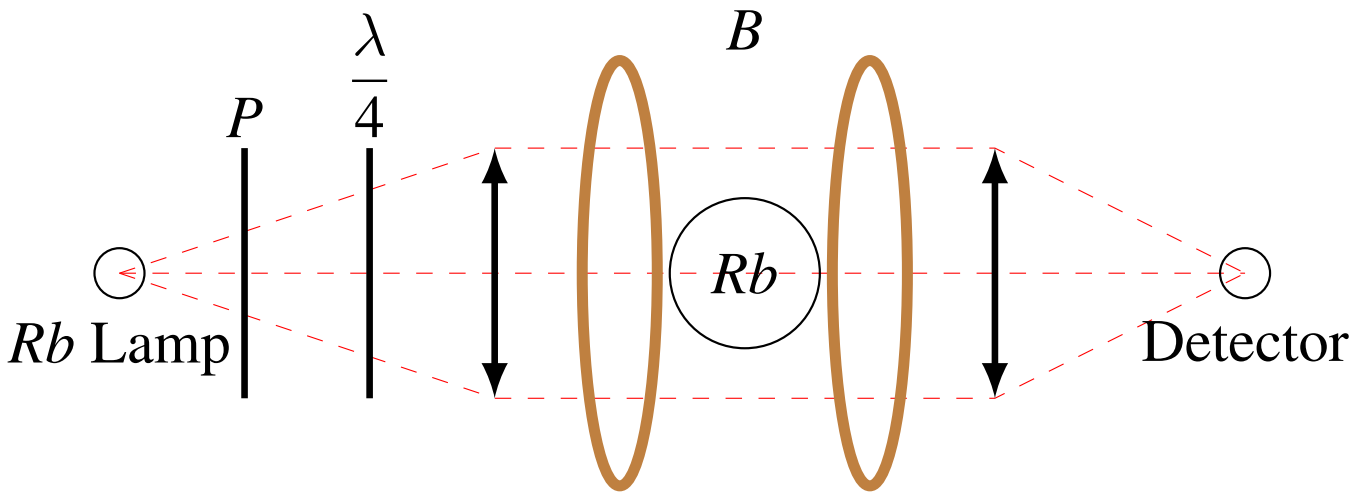

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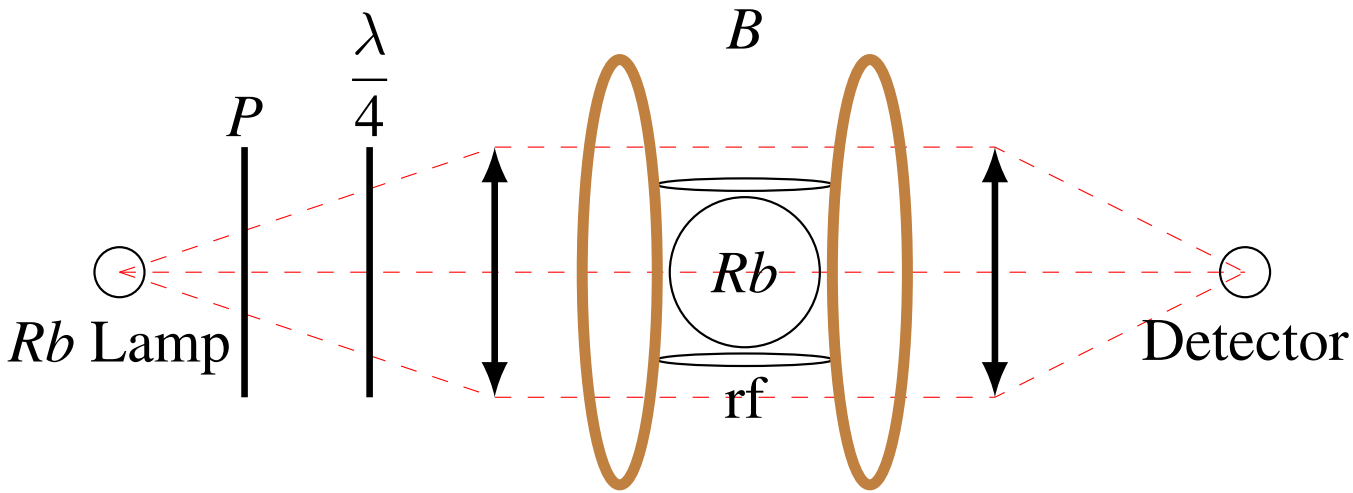

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- B field.
- RF field.

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

Scaning RF frequency at different 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

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

Scan B field at different RF frequency.

- Measure resonance frequency.

Measurement

$$\Delta \mu B = hf$$

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

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

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.

Light intensity when scanning B field.

g_F factor.

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

Scanning RF frequency.

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.

Light intensity when scanning RF frequency.

Natural Abundance.

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

Conclusion.

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

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Landé g-factor

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

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

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

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

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

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