Doppler-free spectroscopy using saturated absorption

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Introduction

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

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1. Doppler broadening and saturated absorption.
2. Apparatus and measurement.
3. Data and result.
4. Conclusion.

Doppler broadening and spectral hole burning.

- Natural line width.
- Doppler broadening.

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

- Cooling.
- He-Ne spectral whole burning discovered by Bennett in 1962.
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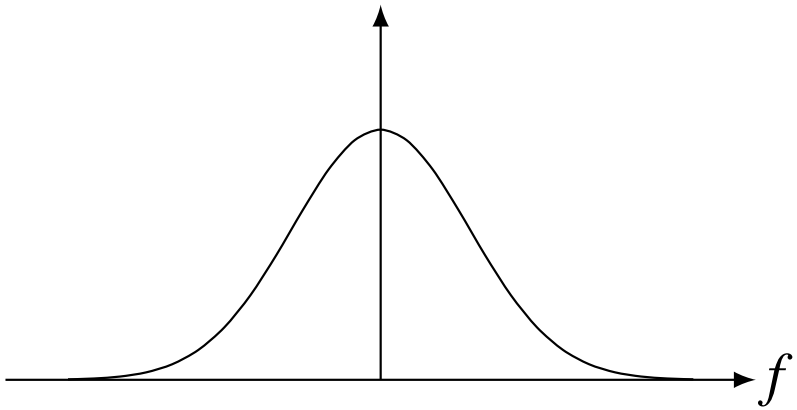

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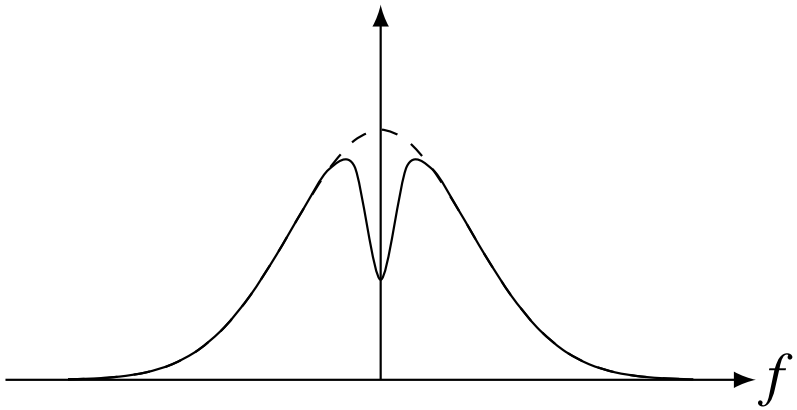

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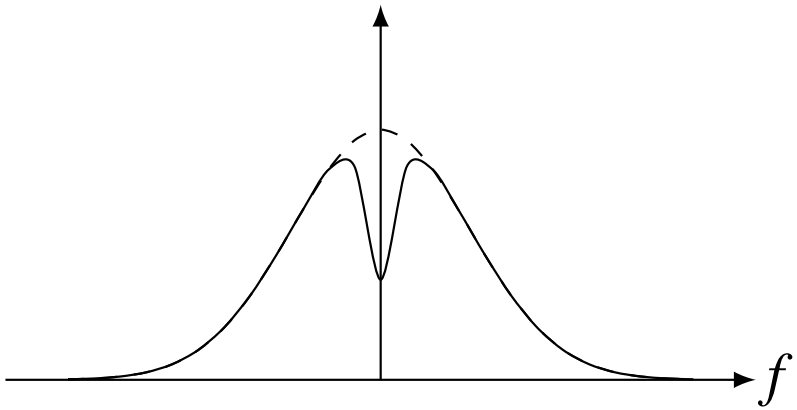

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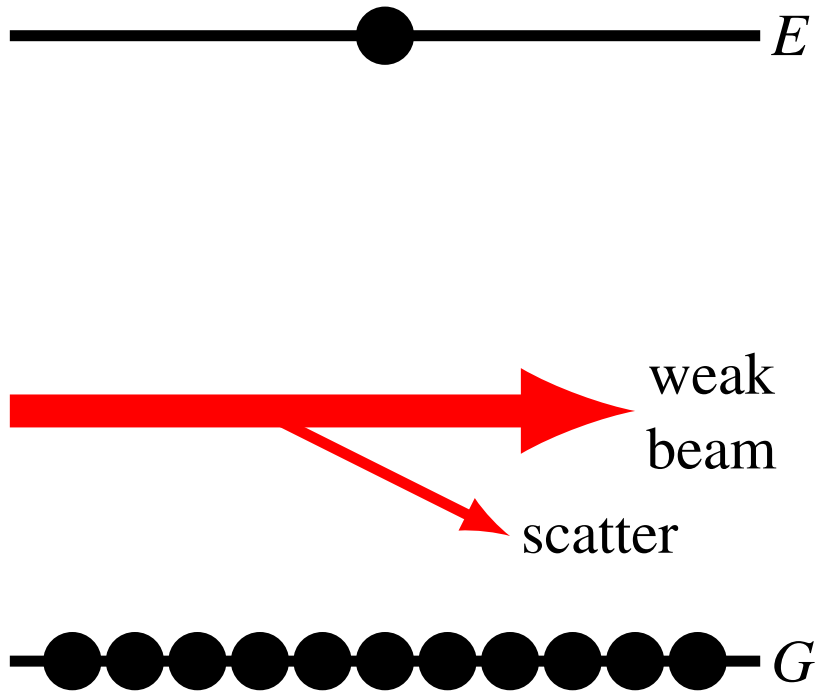
- Saturate absorption with two beams. Velocity selecting and Lamb dip.
- Crossover peaks.



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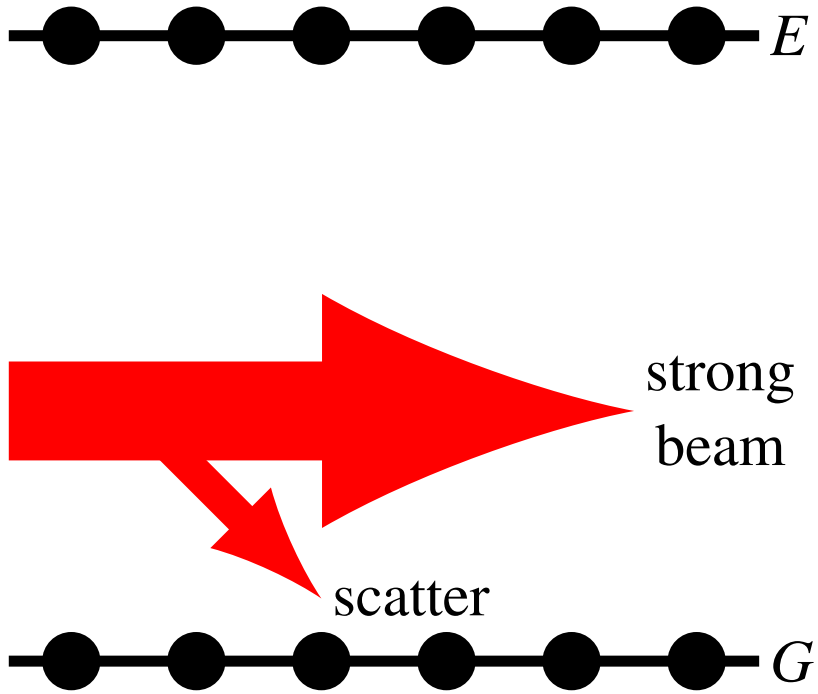

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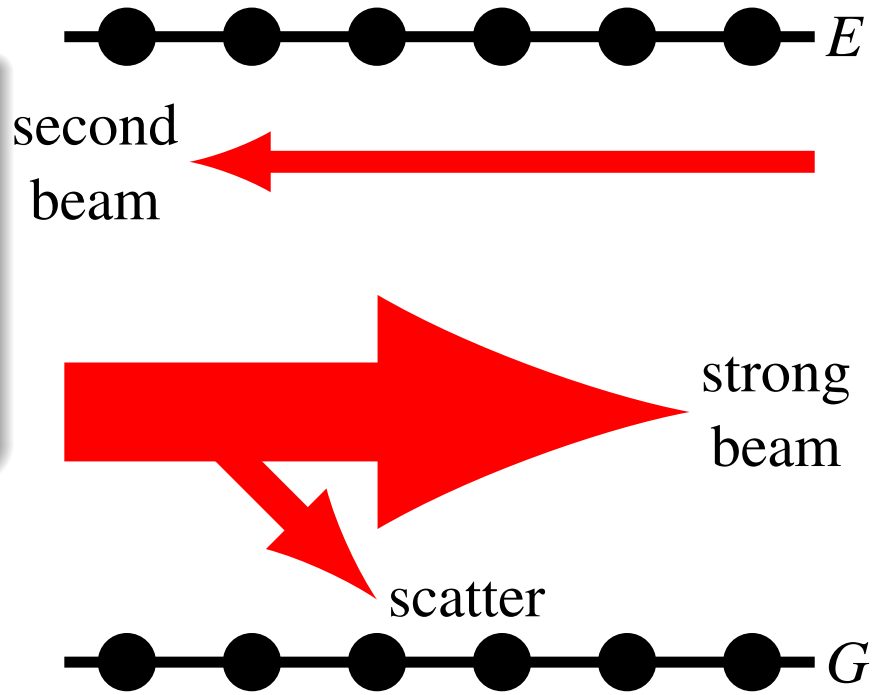

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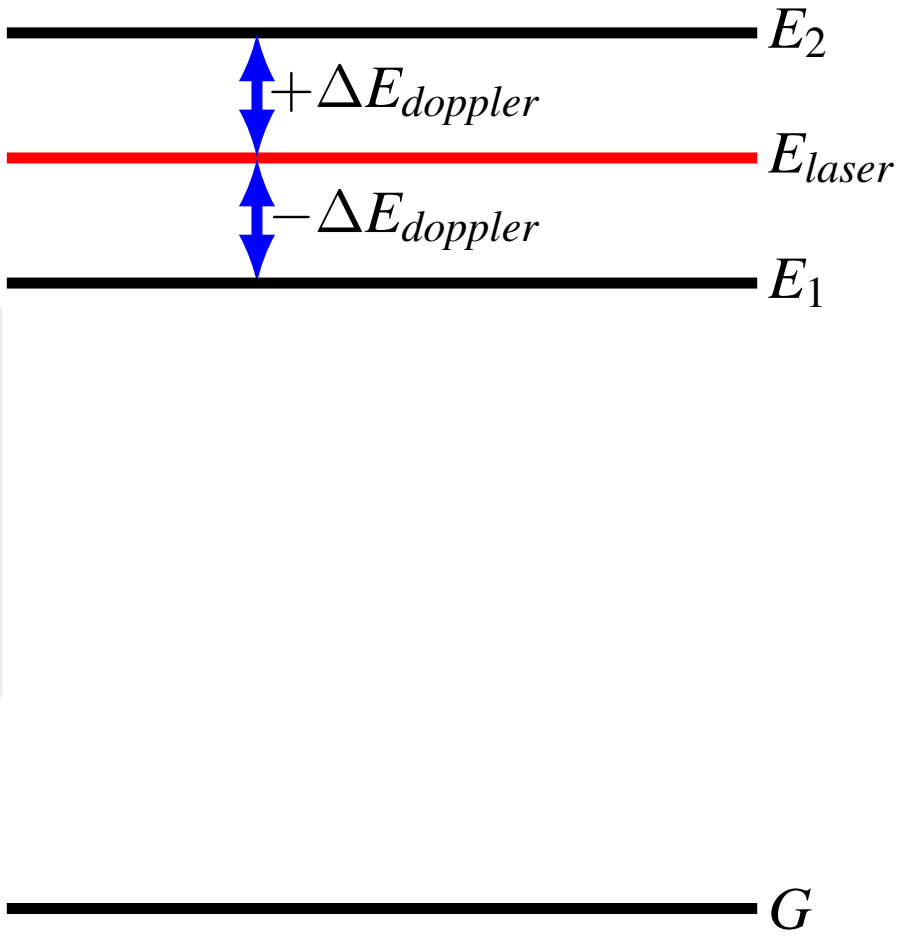

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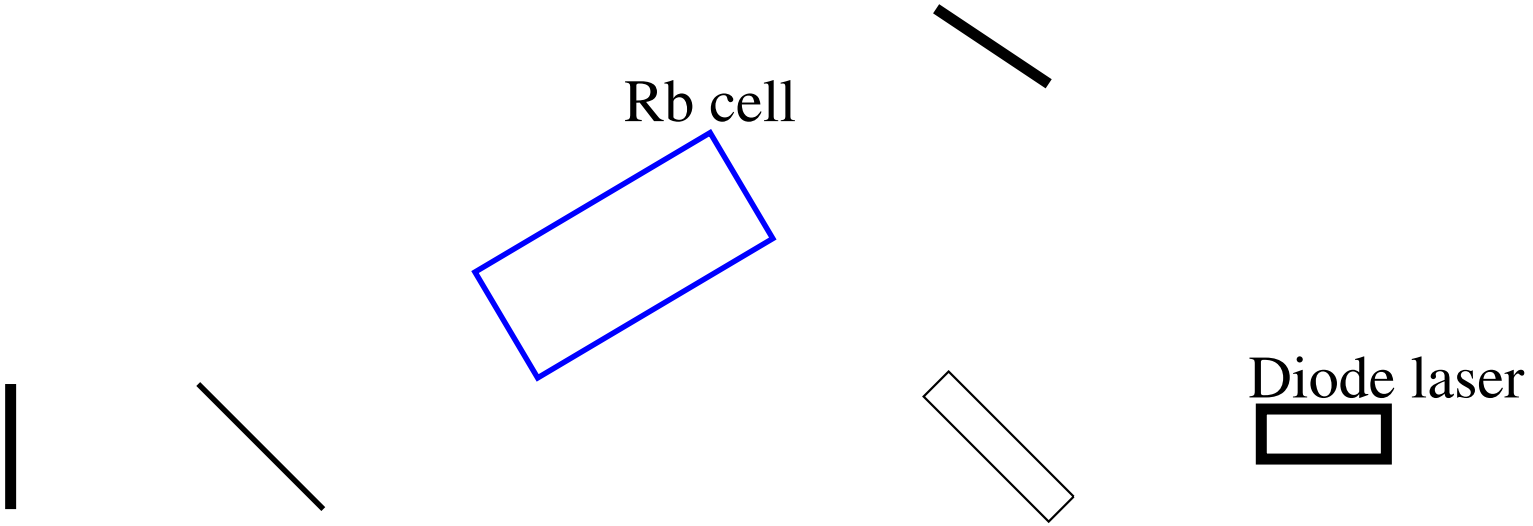

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- Probe and reference beam.
- Fabry-Pérot cavity

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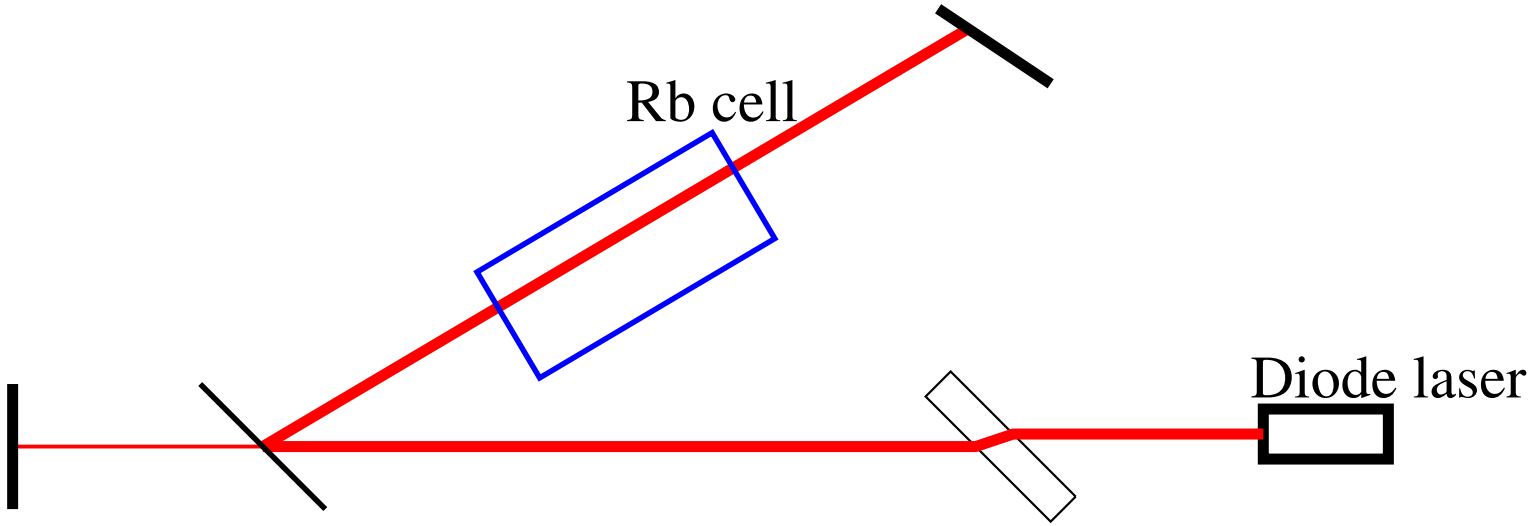

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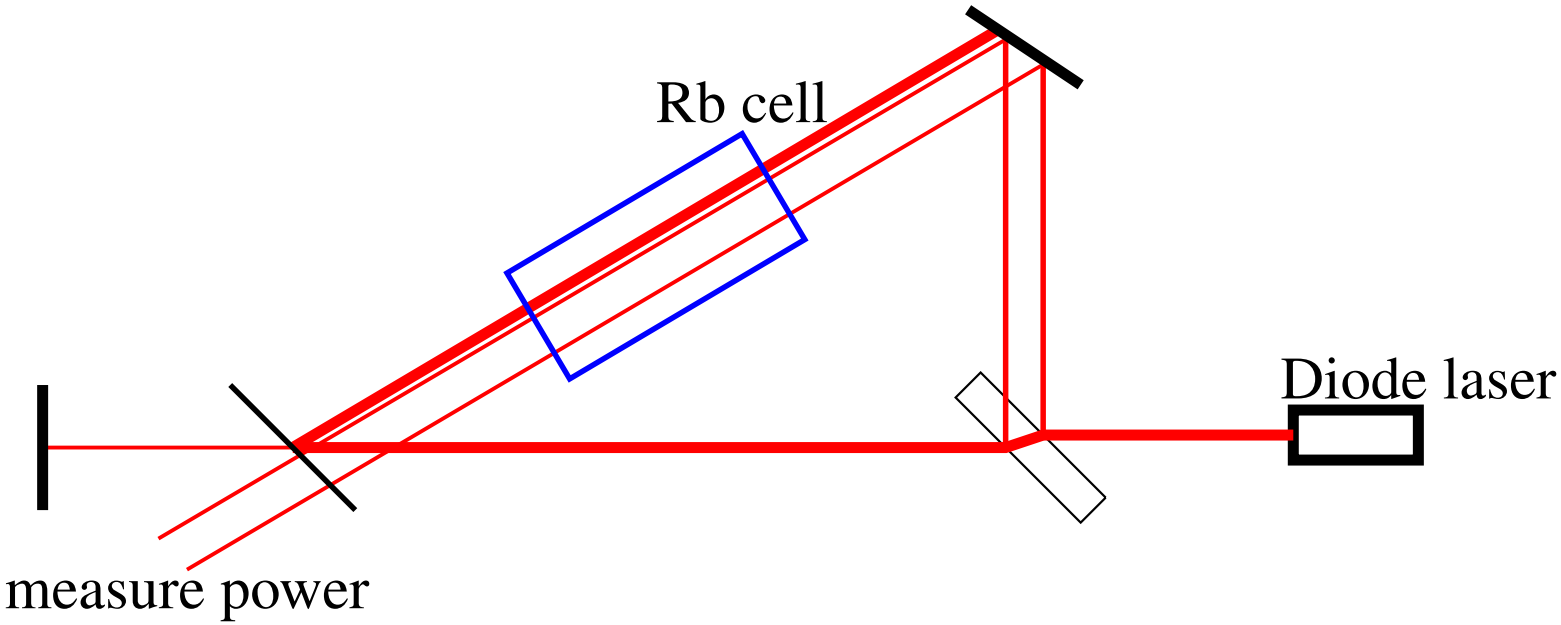

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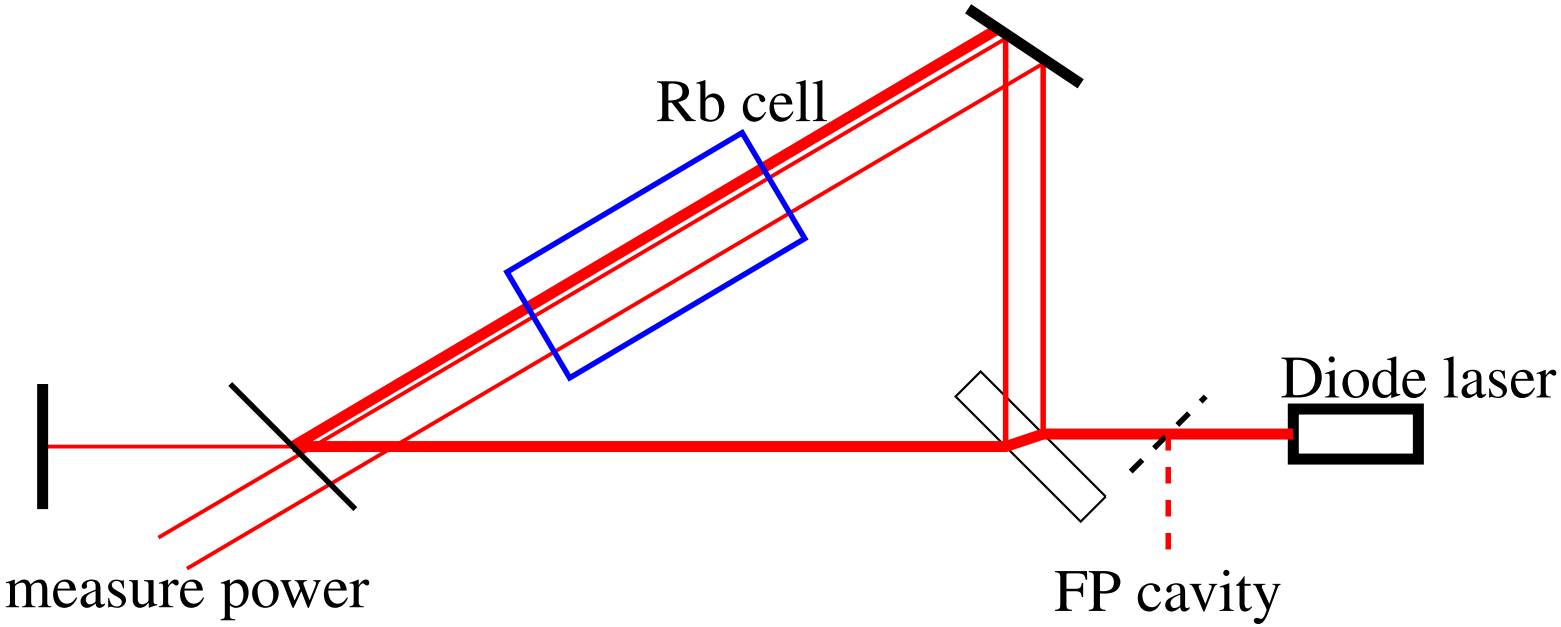

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Measurement

Hyperfine structure of Rubidium D_2 line.

- D_2 line
  $5^2S_{1/2} \rightarrow 5^2P_{3/2}$
- 2 “doppler distinguishable” “ground states”, each couples with 3 non-“doppler distinguishable” excited states.
- $$\Delta E_{hfs} = \frac{1}{2} A_{hfs} K + B_{hfs} \frac{3K(K+1) - 2I(I+1)J(J+1)}{8I(2I-1)J(2J-1)}$$
  $$K = F(F+1) - I(I+1) - J(J+1)$$
- Quantities to measure
  $A_{5^2S_{1/2}}$, $A_{5^2P_{3/2}}$ and $B_{5^2P_{3/2}}$ for ^{85}Rb and ^{87}Rb.

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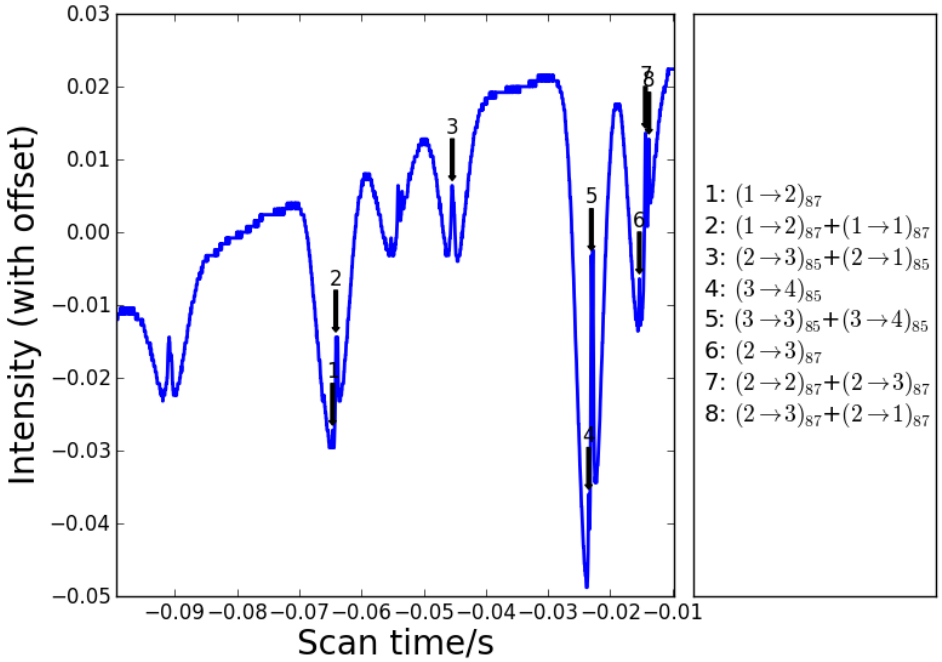

Probe beam intensity of the whole scan.

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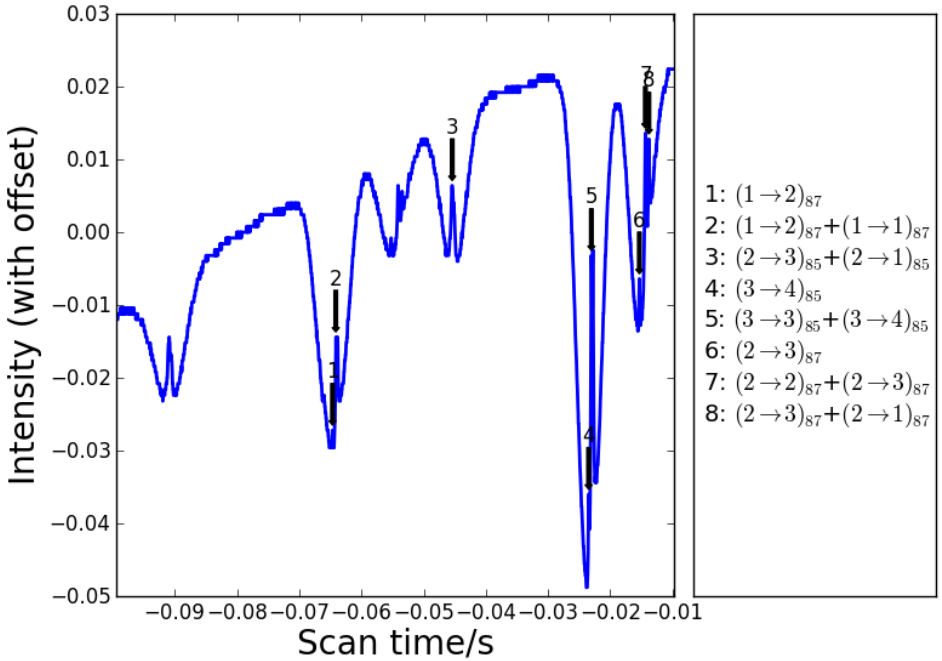

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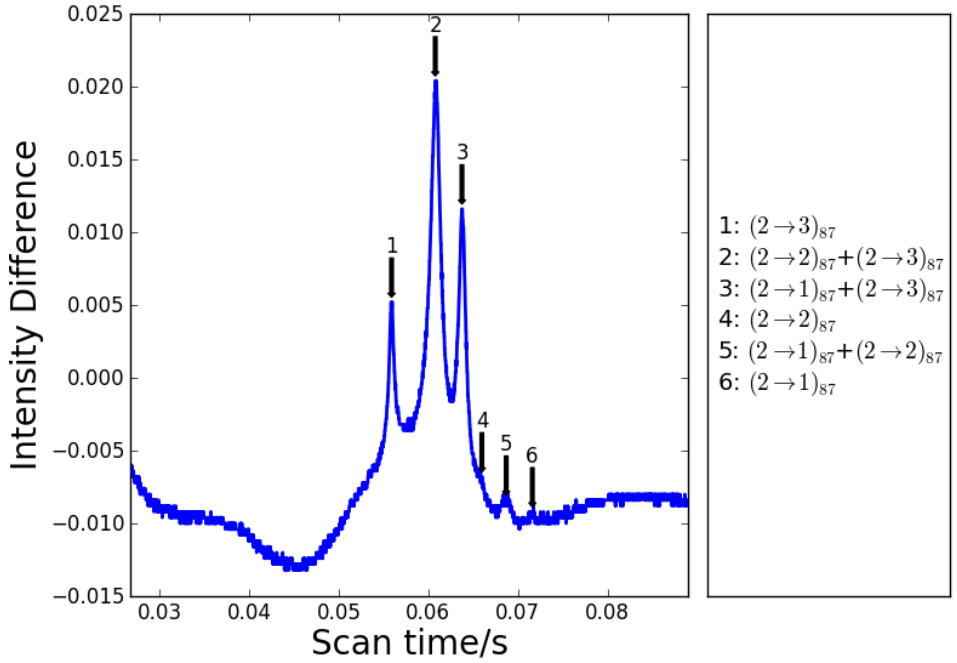

Difference between probe and reference beam intensity of the ^{87}Rb $F = 2$ lines.

Hyperfine Structure Constants.

Isotrope	Constant	Measured	Expected	Deviation
^{85}Rb	$A_{5^2S_{1/2}}$	$0.986(40)GHz$	$1.0119GHz$	0.6σ
	$A_{5^2P_{3/2}}$	$24.44(81)MHz$	$25.0020(99)MHz$	0.7σ
	$B_{5^2P_{3/2}}$	$32.2(4.8)MHz$	$25.790(93)MHz$	1.3σ
^{87}Rb	$A_{5^2S_{1/2}}$	$3.285(65)GHz$	$3.4173GHz$	2σ
	$A_{5^2P_{3/2}}$	$84.58(52)MHz$	$84.7185(20)MHz$	0.2σ
	$B_{5^2P_{3/2}}$	$16.03(80)MHz$	$12.4965(37)MHz$	4σ

Conclusion.

- Observed Lamb dip.
- Measured hyperfine splitting and the hyperfine structure constants.

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