Lab preparation.

To every lab there are exercises to be solved individually beforehand. You must have written solutions (or at least good attempts) to all before you are allowed to participate in the lab.

2-electron systems:

Illustrate *LS*-coupling and intermediate coupling effects . Selection rules and relative intensities.

Research equipment Michelson interferometer (Fourier Transform Spectrometer).

Zeeman effect:

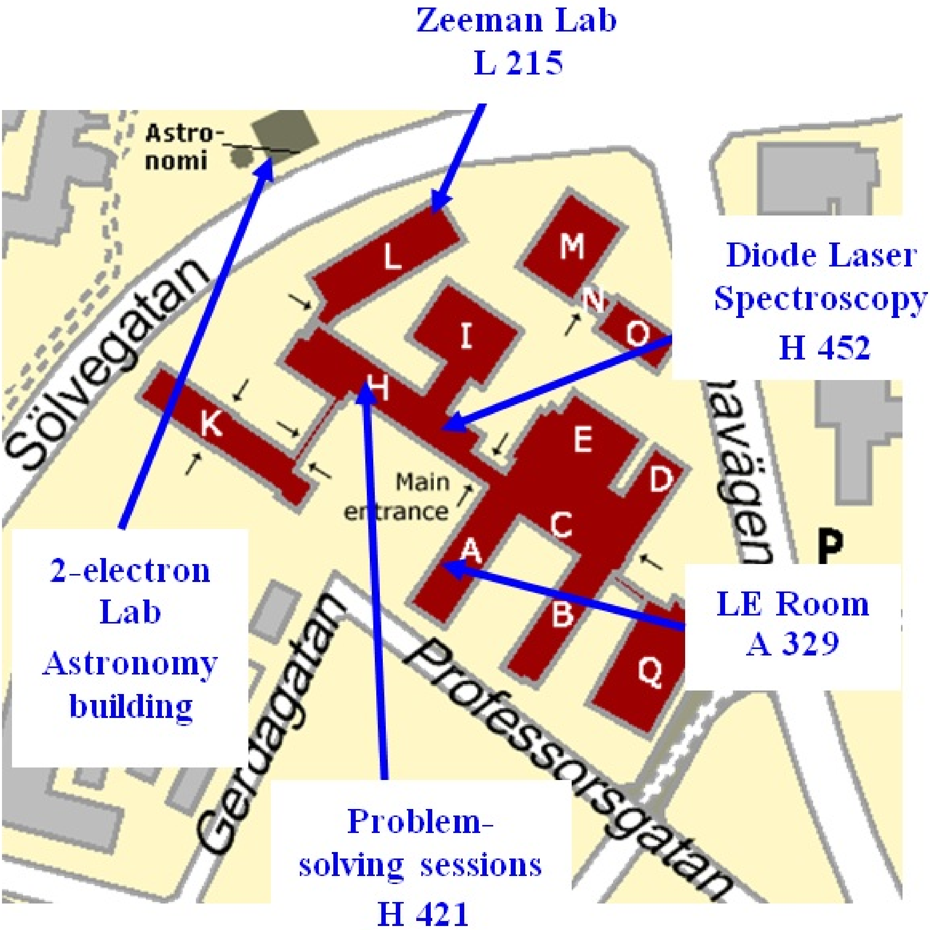
Spatial quantization. Polarization state of light.

Fabry-Perot interferometer.

Diode laser spectroscopy

Hyperfine structure in Rb. Line width and resolution.

Aligning optical components. Fabry-Perot etalon used to generate a frequency scale. Use of a digital oscilloscope.


Zeeman Lab
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Main
entrance
Diode Laser
Spectroscopy
H 452
P
2-electron
Lab
Astronomy
building
LE Room
A 329
Gerdagatan
Professorsgatan
Problem-
solving sessions
H 421

In the Zeeman and diode spectroscopy lab two students will work together on four experimental set-ups, whereas for the two-electron lab all 8 students will use the same research equipment.

For the Zeeman and the two-electron lab you must write a good and detailed lab report. The quality of your work during the lab and your reports will contribute to your grade on the lab part of the course. Reports are written by two students together and you must each contribute about half of the text.

The diode laser lab ends in an oral discussion without any further report and is only graded as pass or fail.

Your final grade on the course will be the weighted average of the lab part and the result on the written exam according to:
Grade=(2.5*Lab + 5*exam)/7.5.

Lab preparation - refresh your optics!

- **Polarized light:**
  - **Description, production and manipulation**
  - **Used in the Zeeman lab**

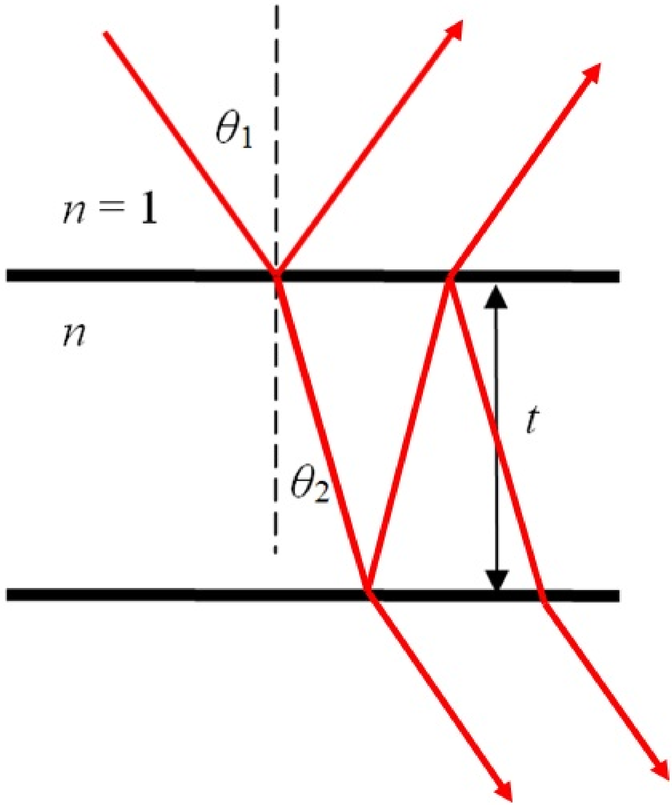
    Revisit your previous lab in optics illustrating, birefringence and optical activity. Retarder plates, especially the quarter-wave plate. See also the Zeeman lab instruction Appendix 2

- **The Fabry-Perot interferometer.**
  - **Used in both the Zeeman and the Diode laser spectroscopy lab**

    Spectrophysics Ch. 13.3, 13.4 and Appendix 1 in the lab instruction: "*The Fabry-Perot interferometer, free spectral range, line width and data reduction for the Zeeman lab.*"

Note also The Michelson interferometer and Fourier-transform spectroscopy in Spectrophysics Ch. 13.5, 13.6 used in the “2-electron systems” lab.

Interference in thin films

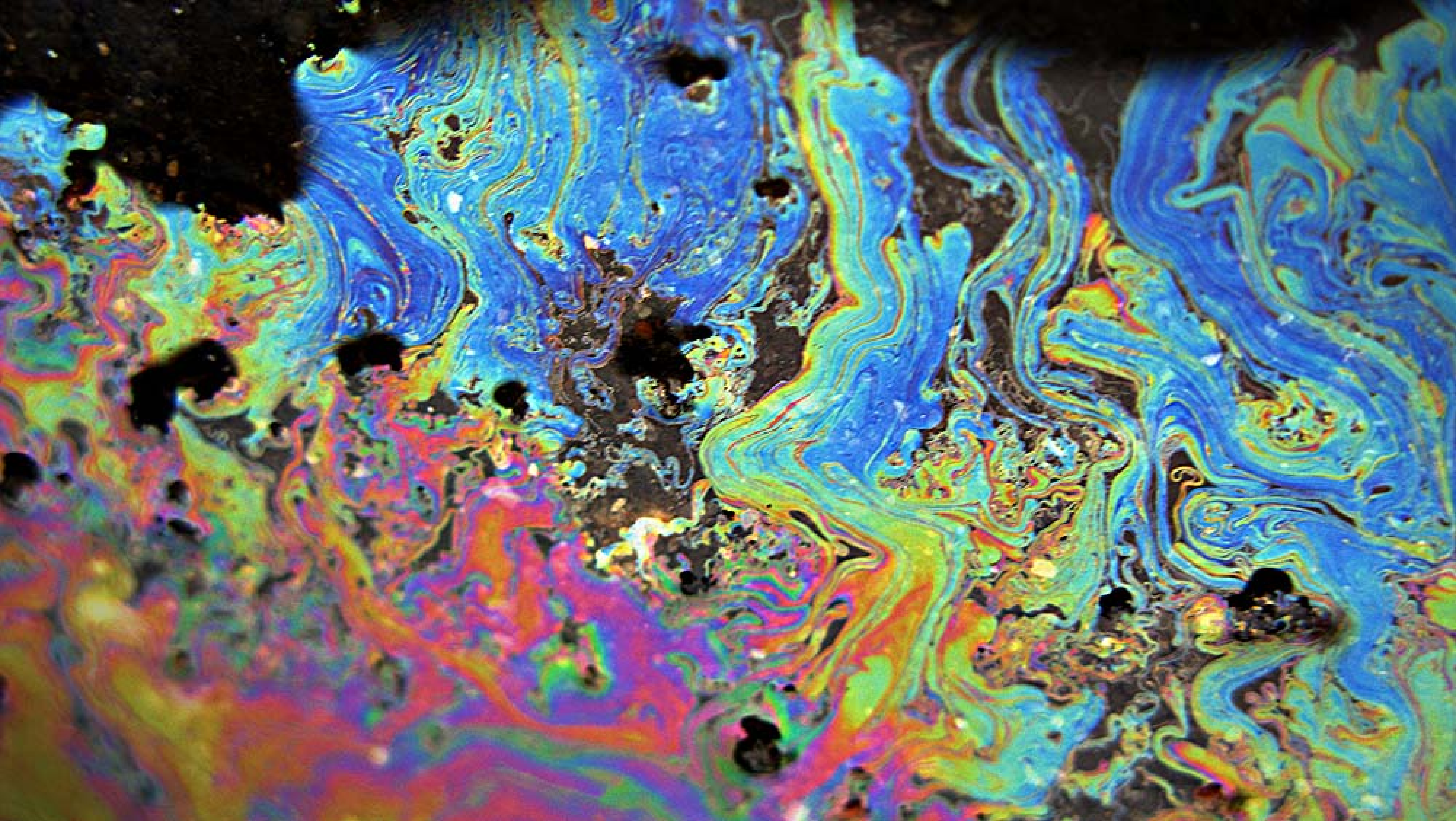


The phase difference between the two outgoing rays is:

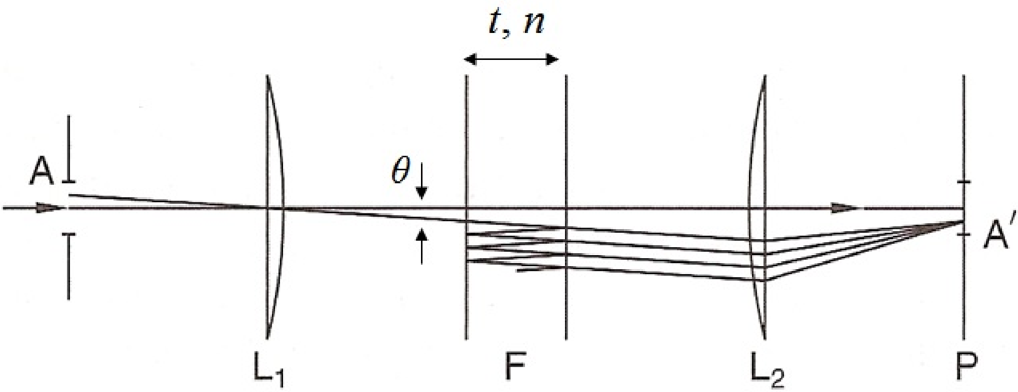
$$\delta = \frac{2\pi}{\lambda_{vac}} 2 \cdot n \cdot t \cdot \cos\theta_2$$

Maximum in the transmitted light intensity:

$$\delta = m \cdot 2\pi \Leftrightarrow 2 \cdot n \cdot t \cdot \cos\theta_2 = m \cdot \lambda_{vac}$$



Fabry-Perot interferometer

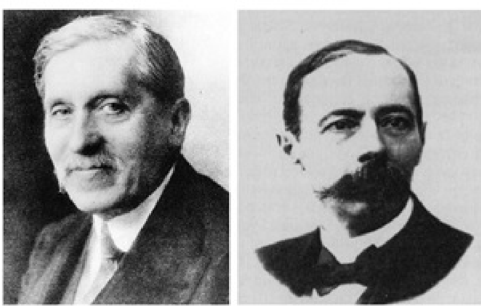


Spectrophysics Fig 13.1.

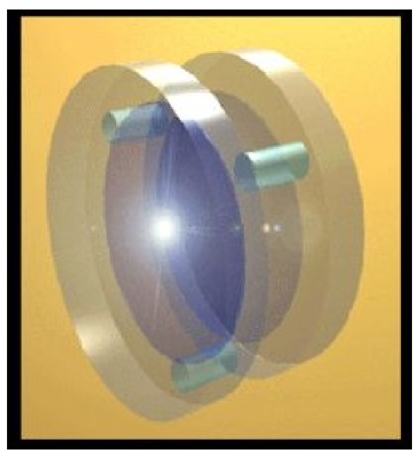
The phase difference between 2 transmitted beams is

$\frac{2\pi}{\lambda} \cdot 2nt\cos\theta$. Maximum intensity if $2nt\cos\theta = m\lambda$

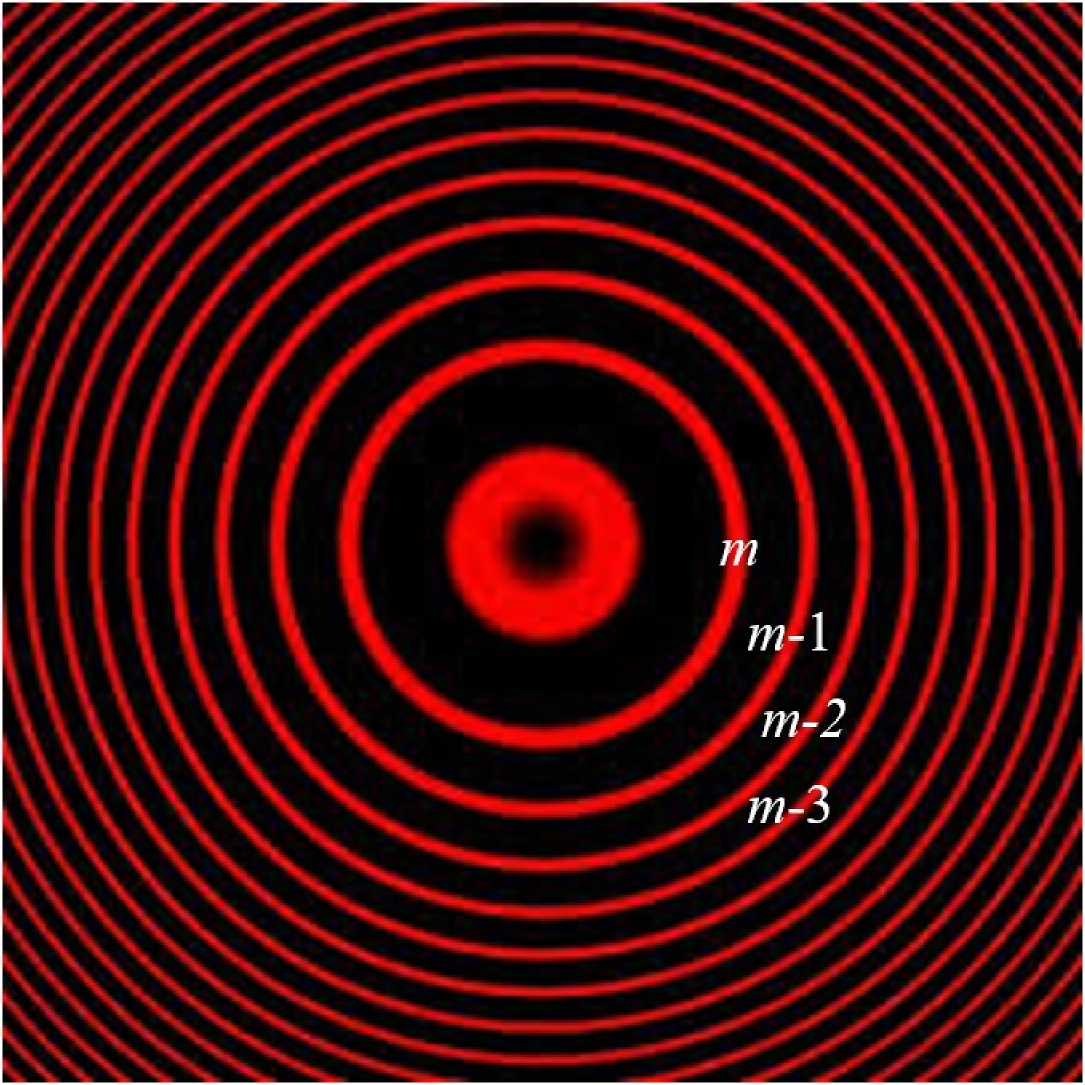
Note rotational symmetry in θ!



Charles Fabry (1867-1945), left, and Alfred Perot (1863-1925),right, were the first French physicists to construct an optical cavity for interferometry

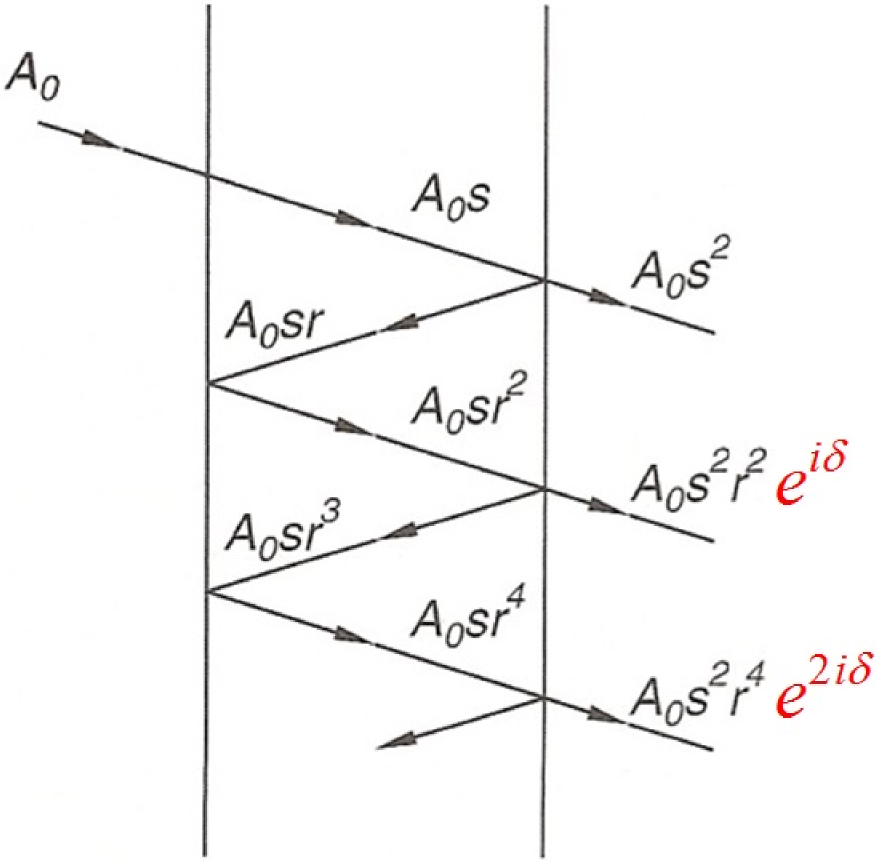


Fabry-Perot with a monochromatic light source



$$2nt\cos\theta = m\lambda. \quad \theta \nearrow \Rightarrow m \searrow$$

The transmission function for a Fabry-Perot interferometer

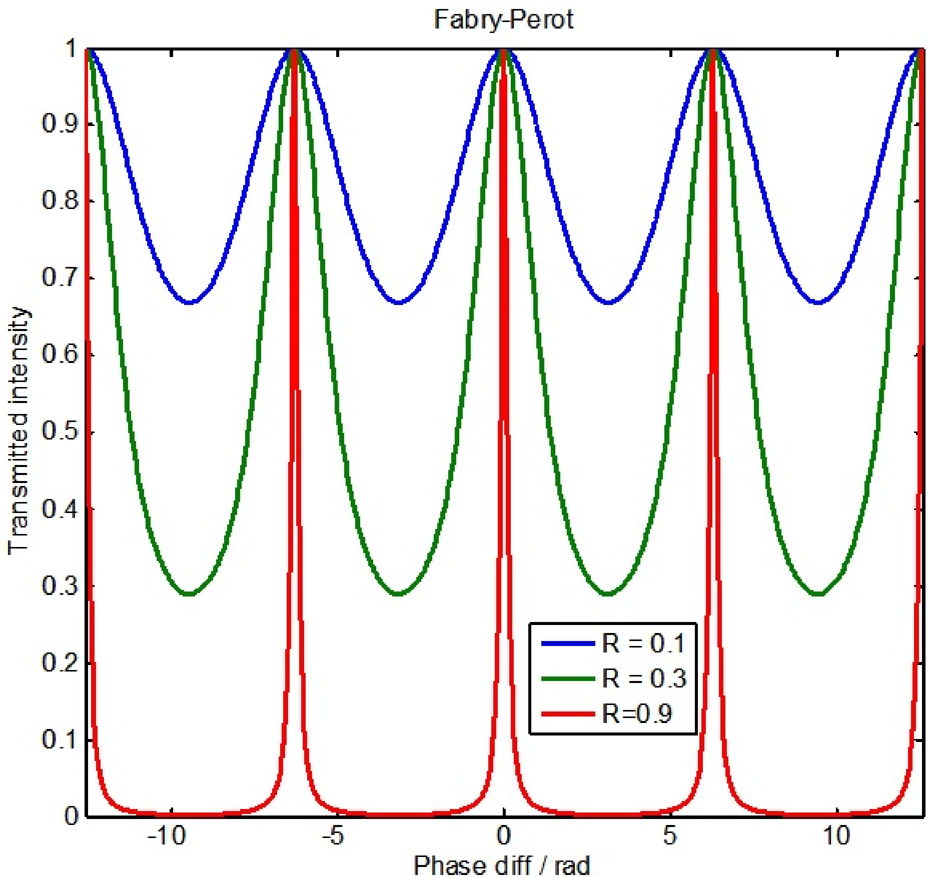


Spectrophysics Fig 13.3 (modified).

s = amplitude transmission coefficient

r = amplitude reflection coefficient

The Airy function

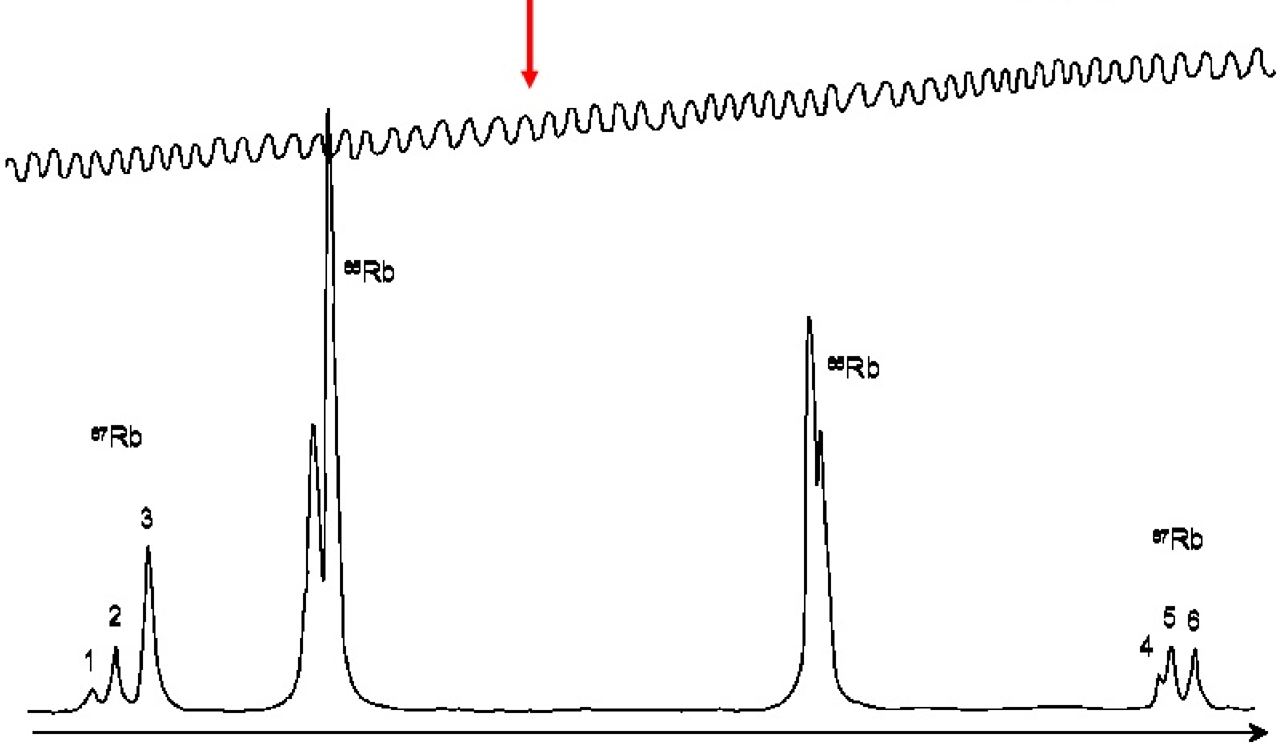


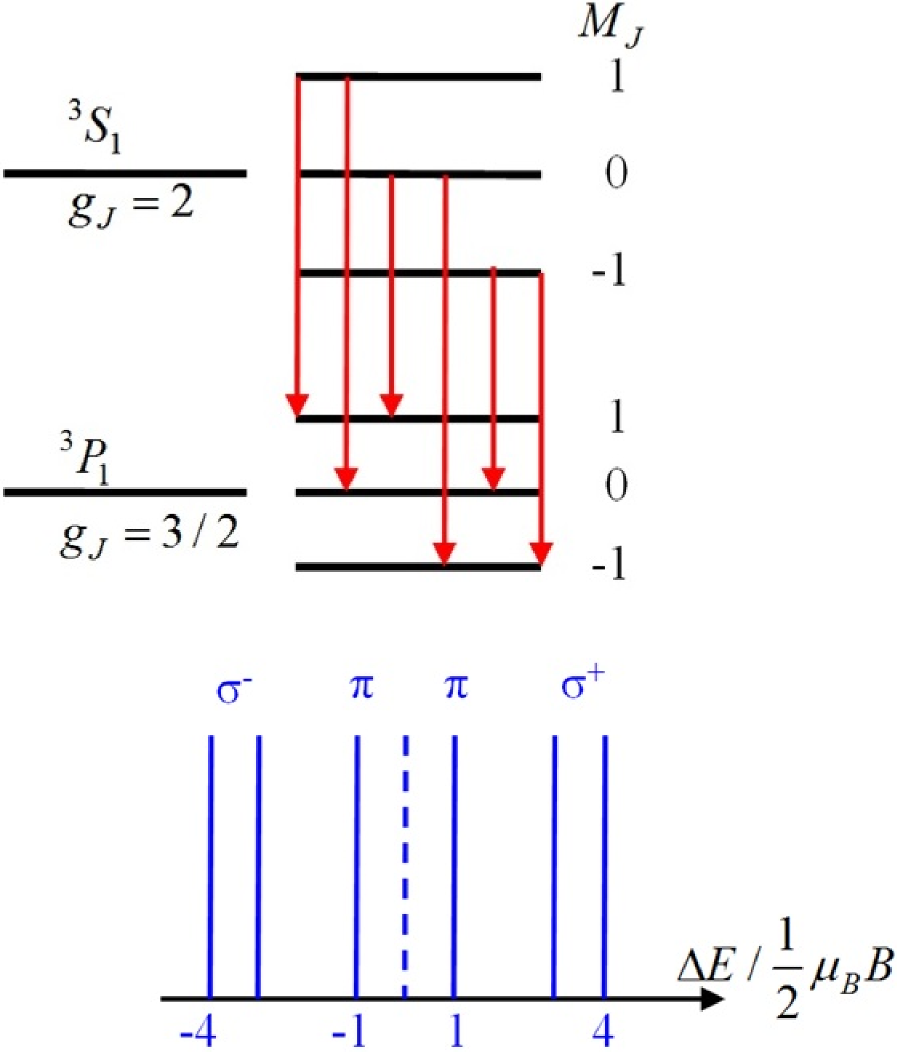
$$I = I_0 \cdot \frac{1}{1 + \frac{4R}{(1-R)^2}\sin^2(\delta/2)}, \quad R = r^2, \quad \delta = \frac{2\pi}{\lambda_0} 2nt\cos\theta.$$

$\Delta\delta_{\text{FWHM}} = 2 \cdot \frac{1-R}{\sqrt{R}}$. Thus as R increases the line width decreases

Example from the diode laser spectroscopy lab

Fabry-Perot-generated frequency scale: $\Delta f = \dfrac{c}{2nL}$





M_J
1
0
-1
1
0
-1
$^3S_1$
$g_J = 2$
$^3P_1$
$g_J = 3/2$
σ⁻
π
π
σ⁺
$\Delta E / \frac{1}{2}\mu_B B$
-4
-1
1
4