Investigation of the Zeeman effect in mercury with the Fabry-Perót interferometer

Aida Álvarez Díez
Supervisor: Tomasz Kawalec

Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University, Kraków, Poland

ABSTRACT

To measure the magnetic field applied to a mercury lamp (λ_0=*546.1 nm*) we use a Fabry-Perót interferometer and the Zeeman effect. Currents of values 20, 30, 40 yield magnetic fields 1.0907±0.0089, 1.555±0.021, and 1.6647±0.0097 T . Most of the results are within our expected values.

THEORETICAL BACKGROUND

The Zeeman effect is the splitting of the spectral lines suffered by an atom when under an external magnetic field. That splitting has an associated energy shift. That shift is given by (1)

$$\Delta E_M = \mu_B m_j g_j B = \frac{eh}{4\pi m_e} m_j g_j B \qquad (1)$$

With c being the speed of light, m_e the electron's mass and e electron's charge.

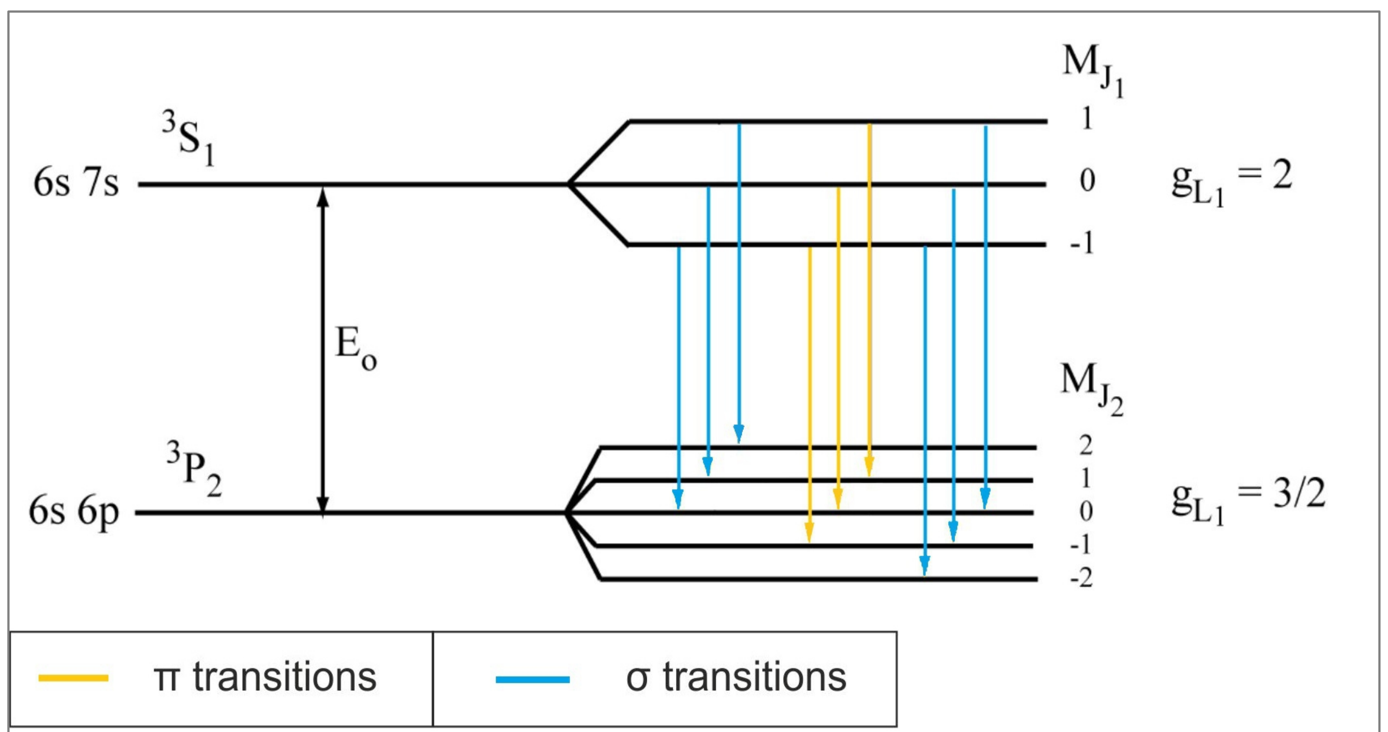
λ_0=546.1 nm corresponds with the transition: $^3S_0 \rightarrow {}^3P_2$

There are two types of transitions, π and σ. We are going to analyze the π transition.

For this case $\Delta g = g_f - g_i = 1/2$

$$B = \frac{8\pi m_e c}{e} \Delta\nu$$

Δν its the frequency change that its calulated from the interference patterns.



$$\Delta E_{trans} = E_o + (g_{L_1} M_{J_1} - g_{L_2} M_{J_2}) \mu_B B \quad = \quad E_o + (g_{L_1} M_{J_1} - g_{L_2} M_{J_2}) \Delta$$

Fig.1: Representation of the splitting of orbitals caused by a magnetc field, and the different type of transtions;of the mercury in the transition λ_0=*546.1 nm*

EXPERIMENTAL SET UP

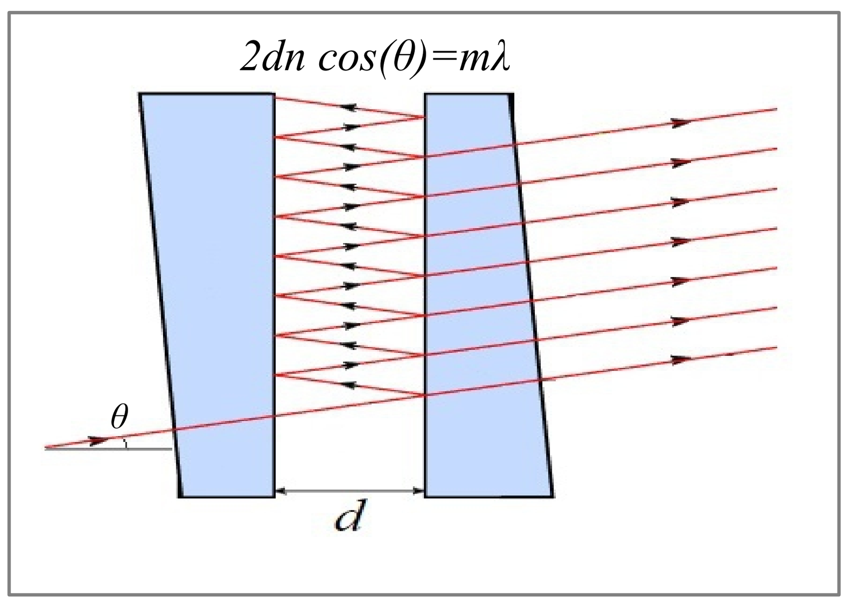


Fig.2: Squeme of the Fabry-Pérot interferometer. With *d* being the distance between the two mirrors, *θ* the incident angle with the first mirror, *n* the refractive index of the material between the two mirrors and *m* the interference order

The parameters of our Fabry-Pérot are:

- R = 0.94(01)
- *d = 3.54 mm*
- *F.S.R.= 42.373±0.060 GHz*. The *F.S.R.* is the spacing in frequency between two successive transmitted optical intensity maxima.
- Finesse ≈ 50
  The finesse is the effective number of times that the light has bounced inside the Fabry-Pérot.

INTERFEROGRAM

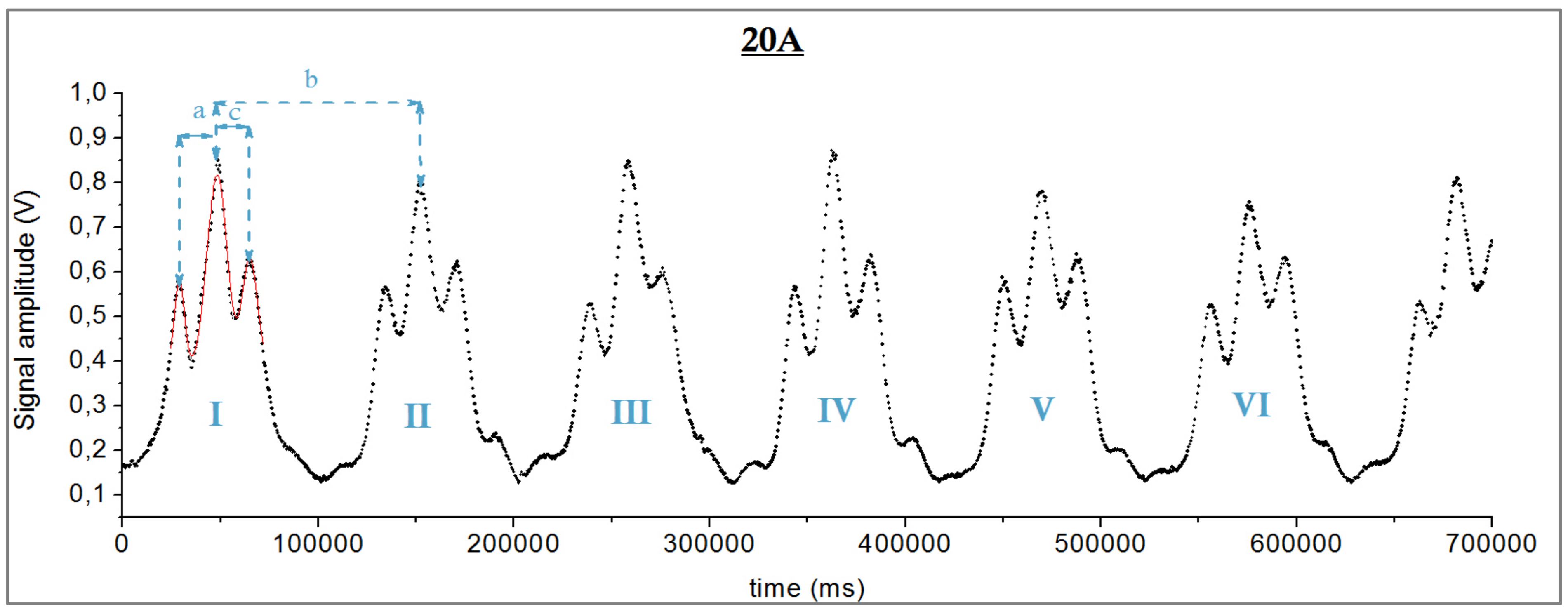


Fig.4: Pattern of π transition measured for a mercury lamp (λ_0=*546.1 nm*) along with the fit for the first set of peaks at 20A

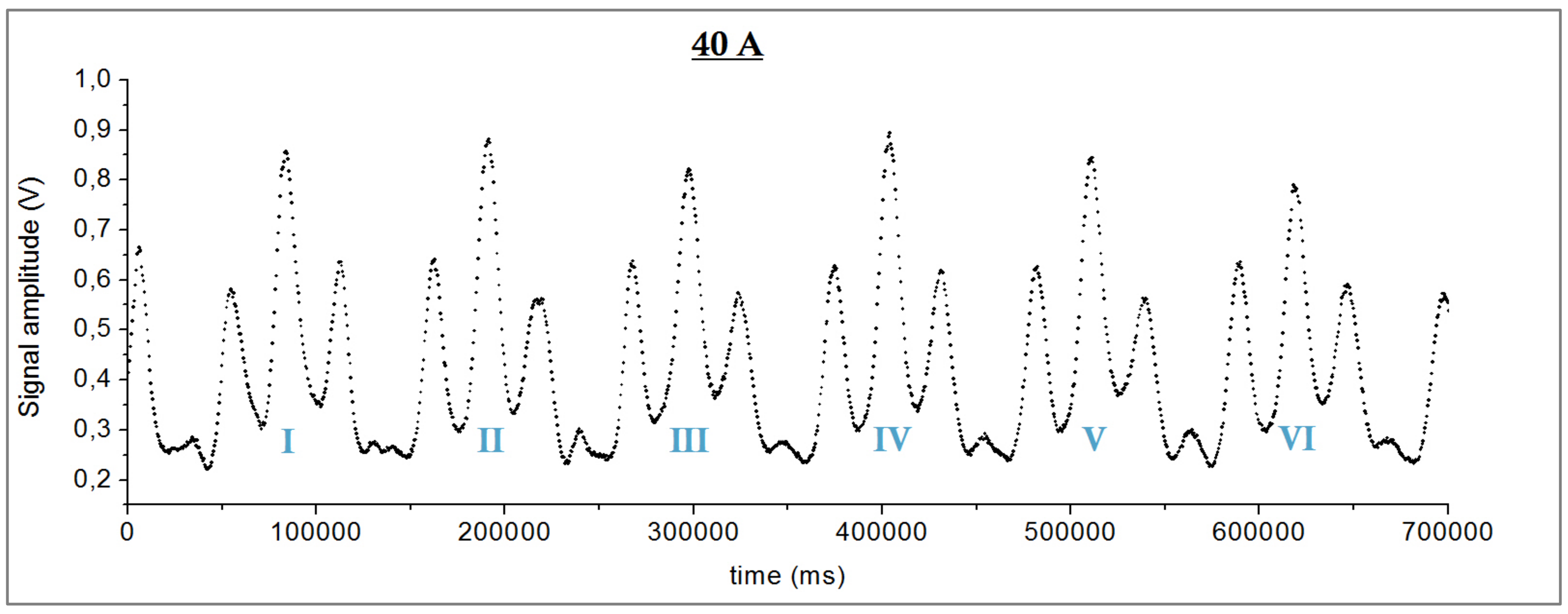


Fig.5: Pattern of π transition measured for a mercury lamp (λ_0=*546.1 nm)* at 40A

LINEARITY OF n(t)

A constant flux of CO_2 is needed to obtain a linear increasing of the refraction index (n) inside the Fabry-Pérot.

To check this we plot the number of the set of peaks (I, II, III...)vs the time that corresponds to the higher maxima of each set . If the data is indeed linear, the slope of the fit is equal to the inverse of the parameter b of Fig.2 and 3. We can use this parameter to calculate the wavelength of the transitions with (2)

$$\Delta\nu = \frac{\bar{a}}{\bar{b}} F.S.R. \qquad (2)$$

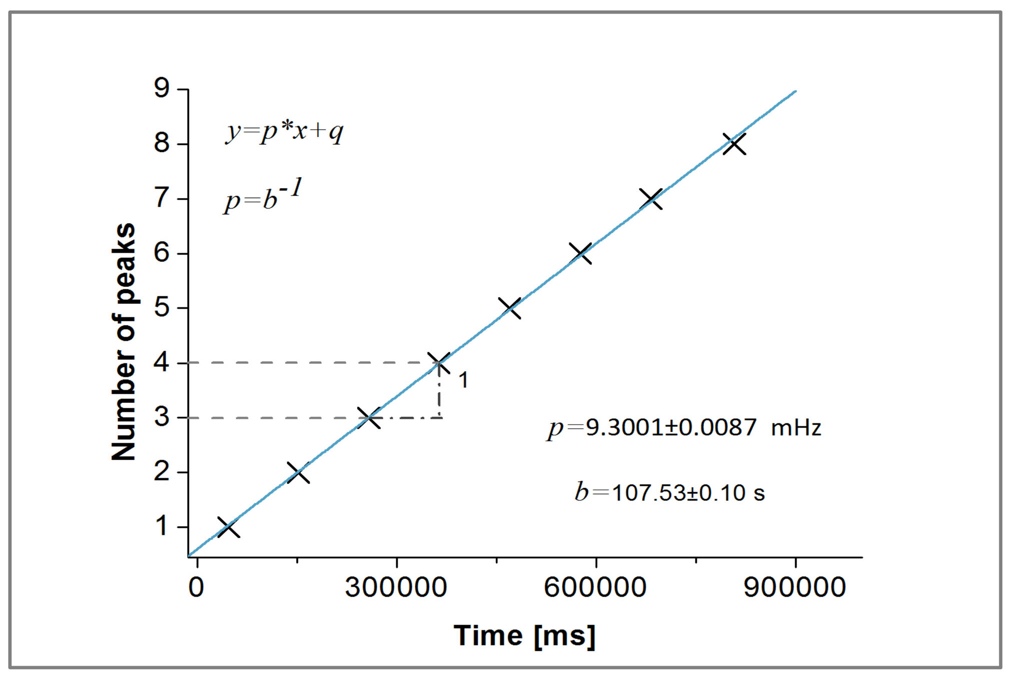


Fig.6: Linearity of the scans for 20A

RESULTS

I[A]	*ν* [GHz]	B[T]
20	7.633±0.062	1.0907±0.0089
30	10.88±0.15	1.555±0.021
40	11.650±0.068	1.6647±0.0097

Frequency's uncertainty is calculated by taking into account two sources of error. The first one is the uncertainty obtained by the fitting of the pattern and the second one is due to averaging.

LITERATURE

- S. Tolansky, "High resolution spectroscopy
- http://courses.washington.edu/phys432/zeeman/zeeman_effect.pdf

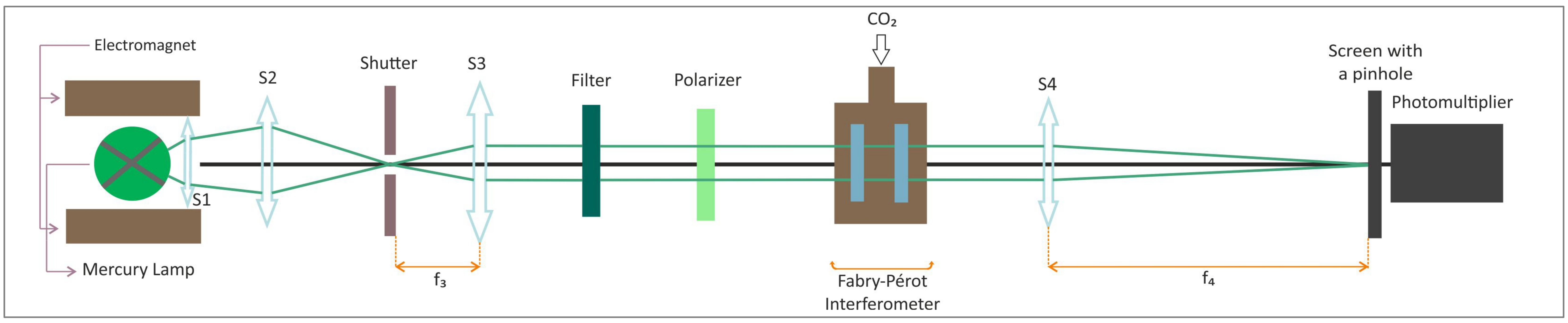


Fig.3.: Scheme of the experimental set up used. f_3 and f_4 stand for the focal distance of lens 3 (S3) and lens 4 (S4)