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 Try to keep your books closed. Discuss with your fellow students to come to an answer.
 Show your work.

Name: _____

1. The Na D lines consist of two transitions at 589.6 nm and 589.0 nm, see also final slide of today's lecture.

(a) Calculate the transition energy and energy separation in eV. Do the same in frequency.

$$E(\text{eV}) = \frac{hc}{\lambda} \quad \text{planck constant } h = 6.626 \times 10^{-34} \quad \text{speed of light } c = 3.0 \times 10^8 \text{ m/s}$$

$$E_1 = 2.1057 \text{ eV (589.6 nm)}, \quad E_2 = 2.1079 \text{ eV (589.0 nm)}$$

$$\Delta E \approx 0.0022 \text{ eV} = 2.2 \text{ meV}$$

$$\nu_1 = \frac{c}{\lambda_1} = 5.0847 \times 10^{14} \text{ Hz}, \quad \nu_2 = \frac{c}{\lambda_2} = 5.0899 \times 10^{14} \text{ Hz}$$

$$\Delta \nu = \nu_2 - \nu_1 = 5.2 \times 10^{11} \text{ Hz}$$

- (b) You want to build a Fabry Perot Interferometer ("planar cavity") that can separate the two lines. What ~~minimum~~ ^{maximum} free spectral range is required to separate lines? In what cavity length does this translate?

Free spectral range (FSR) $\leq \Delta \nu$ to separate two lines

$$\Delta \nu = 5.2 \times 10^{11} \text{ Hz}$$

$$\text{FSR} = \frac{c}{2L} \leq \Delta \nu = 5.2 \times 10^{11} \text{ Hz}$$

$$\therefore L \geq \frac{c}{2\Delta \nu} = 288 \mu\text{m}$$

2. In moodle you can find a paper on cavity-ring-down spectroscopy called CDR.pdf

- (a) Calculate / estimate the resolution of the spectra in Fig. 8 in eV. Remember that a wavelength of 1000 nm corresponds to a photon energy of 1.24 eV.

$$1000 \text{ nm} = 10^{-4} \text{ cm}$$

$$\text{wave number} = \frac{1}{1000 \text{ nm}} = 10^4 \text{ cm}^{-1}$$

$$10^4 \text{ cm}^{-1} \Longleftrightarrow 1.24 \text{ eV}$$

$$2 \text{ cm}^{-1} (\text{from the paper}) \Longleftrightarrow 0.25 \text{ meV} = 2.5 \times 10^{-4} \text{ eV}$$

- (b) In the schemativ of the setup, you find an "Etalon". Based on todays lecture, describe and explain the working principle of an Etalon. What is it used for in this context?

An etalon is a special kind of Fabry-Perot interferometer, which allows only specific frequencies of light to go through. It can be seen as an optical filter.

The etalon consists of a highly reflective plate on both sides and therefore, works similar to a cavity.

By changing distance d , we can select the frequency

