Index of refraction of gases

by Martin Schroedter, Fall 2000

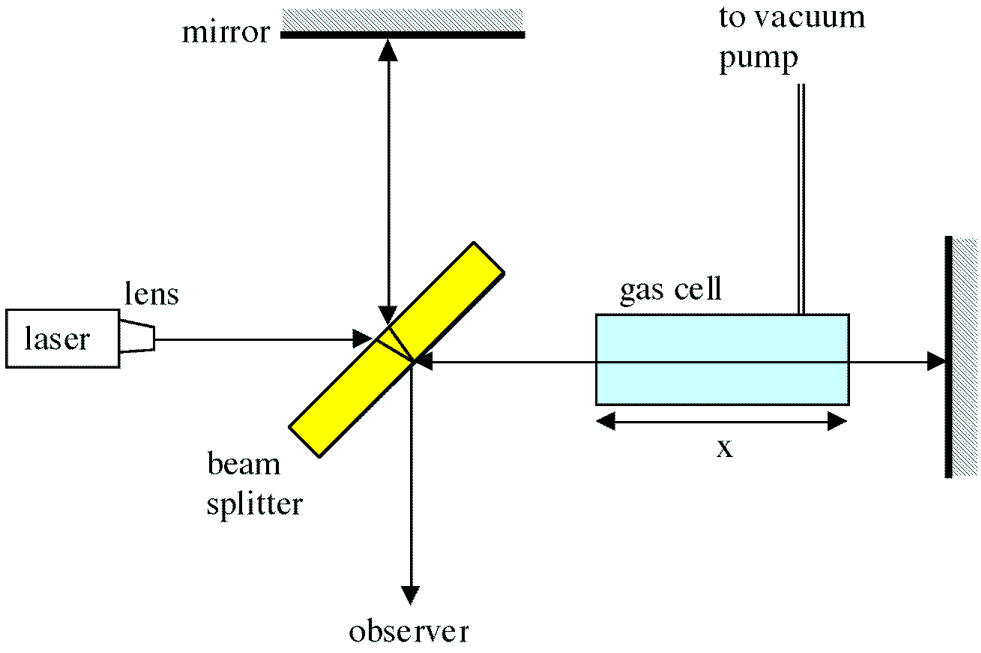
■ Goals

To determine

- the index of refration (n) of air, Ar, and CO_2 at standard atmospheric pressure P_s

■ Introduction

The index of refraction is caused by the dielectric polarizability of atoms. This, however, is of no relevance in this lab. Suffice it to say that for low density ρ the relation between n and ρ is rather linear. You will establish this linearity for three gases. A Michelson interferometer is used to measure the change in optical path length of laser light (λ = 633 nm) in a gas cell. By counting the number of fringes N passing by as the pressure P in the cell is decreased, one can obtain the index of refraction at any arbitrary pressure.



■ Hints to derive the working equation

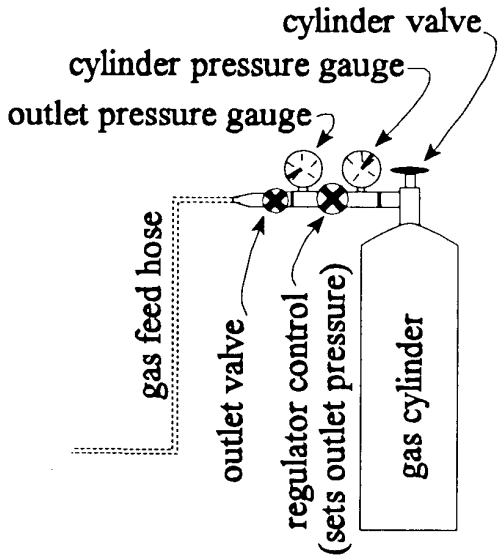
$$n[P_s] = \frac{\lambda}{2x}\frac{dN}{dP}P_s + 1$$

- Using familiar optics principles, relate the change in the number of fringes N to the change in optical path length.

■ Procedure

- Calibrate the dial pressure gauge by use of the U-tube manometer. **Be careful not to let the liquid Hg shoot out.**
- Set up the Michelson interferometer without the gas cell.
- Insert the gas cell and the diverging lens.
- Fill the cell with a gas and devise a way to make sure that the cell is indeed filled with the gas that you want.
- Make a sketch of the set-up that you used.

■ Safe handling instructions for high pressure gas tank / regulator



Graphics © R. Haar

To flood the system with CO_2 and Ar, you will need to use the compressed gas cylinders.

Have a TA review this process with you before you use the equipment.

Purging any remaining gases in the gauges:
- Open the outlet valve, and turn out (counterclockwise) the regulator valve until it is loose.

Setting outlet pressure:
- Open the cylinder valve and read the cylinder pressure gauge to know the pressure inside the cylinder. If it is below 200 psi, please inform your TA.
- Slowly turn in (clockwise) the regulator control while watching the outlet pressure and listening for gas flow. Now close the outlet valve.
- To flood the system with the gas, set the outlet pressure to about 5 psi, and connect a hose to the gas outlet. Evacuate the system with the hand pump and slowly open the outlet valve slowly until the pressure gauge on your interferometer system returns to 0 psi (atmospheric).

When you are done with the experiment:
• Close the cylinder valve, turn out (counter clockwise) the regulator valve, close the outlet valve.

■ Questions

1. What is the purpose of the diverging lens?

2. Why should the pressure be changed slowly during data taking? Think about the ideal gas law.

3. How can you obtain n at standard temperature T_s? I.e.: How does n vary with temperature? Perform the temperature correction to compare your results to the values in the *CRC Handbook of Chemistry and Physics*.

4. Is the wavelength of the He-Ne laser given in air or in vacuum? Estimate the resulting uncertainty in your value for $n[P_s]$.

■ Additional hints

• Be careful in deriving the error propagation equation. It is best not to use the cookbook formula, but to work it out from scratch.