

## Assignment 6

1. What is the Lamb dip?
2. Derive the Schawlow Townes expression for the laser linewidth. Estimate it and explain why most lasers have a much larger linewidth.
3. Consider a single frequency dye laser tuned to the center of the sodium D line at 589 nm and irradiating a heated cell (630 °K), 10 cm long, containing a mixture of sodium vapor at a density of  $1.5 \times 10^{15} \text{ cm}^{-3}$  and helium gas at a density of  $6.53 \times 10^{19} \text{ cm}^{-3}$ . The self-broadening of this line, caused by collisions between sodium atoms is 15 MHz for the conditions of this problem. The foreign gas broadening is due to collisions between sodium atoms and helium with a cross section estimated to be  $10^{-14} \text{ cm}^2$ . Consider the following data for this transition.

$$N_1 \ 3^2S_{1/2} \ g_1=2, \ E_1 = 0$$

$$N_2 \ 3^2P_{3/2} \ g_2=4 \ E_2 = 16978,07 \text{ cm}^{-1} \ A_{21} = 6.3 \times 10^7 \text{ sec}^{-1}$$

- a) What are all of the pertinent linewidths from the various causes (“natural”, Doppler, self-broadening, or foreign gas (He) collisions)?
- b) If a “small-signal” laser is tuned to line center and propagates through the 10 cm length, what fraction emerges?