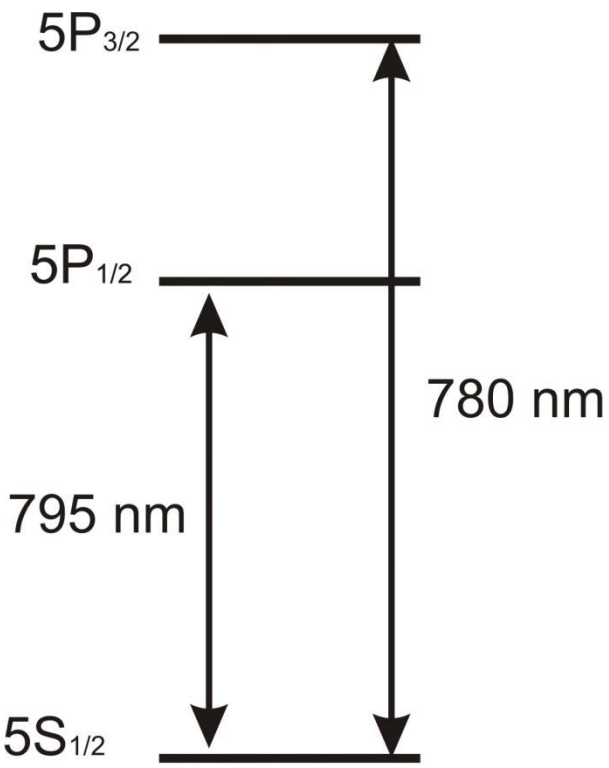
Phys 4061/5061 – Tutorial Three

Details Pertaining to laboratory experiments covered in this tutorial can be found in the lab manual under the following sections

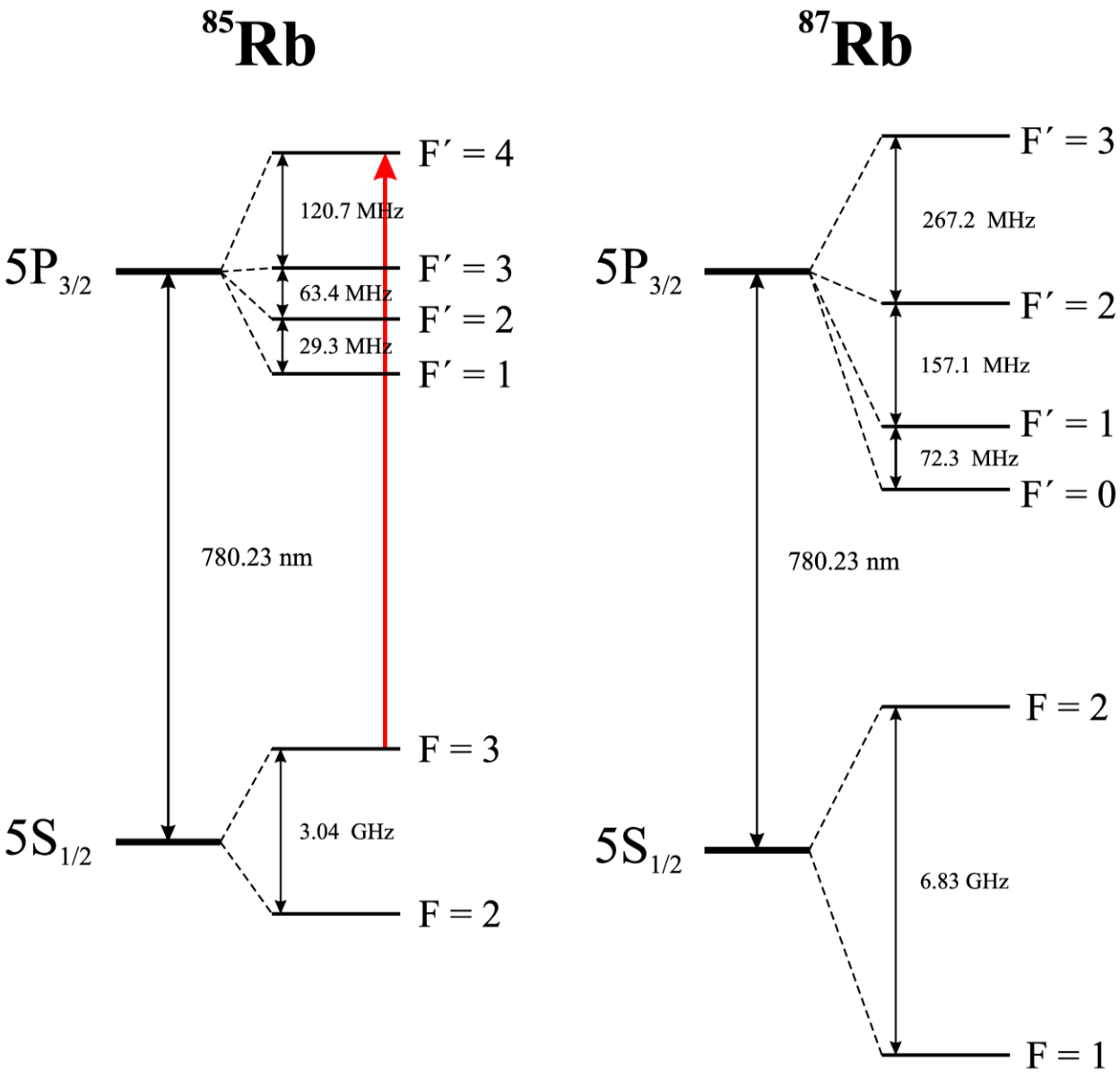
1. Absorption/Emission Spectroscopy
2. Lockin
3. Zeeman Shift

Figure One



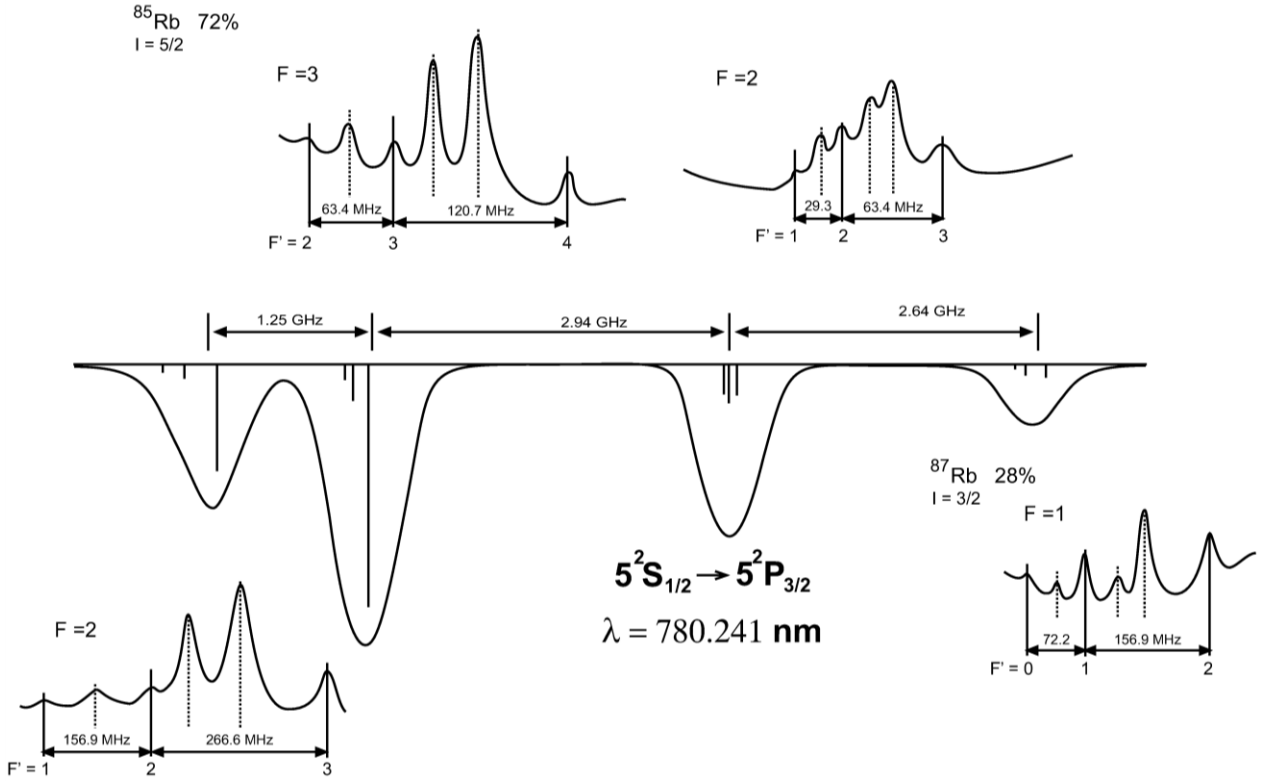
Experiments in Phys 3220 involve spectroscopy of fine structure transitions in Na and Pb.
In this course we use a laser with a line width of about 1 MHZ. Therefore, using saturated absorption spectroscopy we can study the hyper fine level splittings associated with the 780 nm transition.

Figure Two



Energy level diagrams for ^{85}Rb and ^{87}Rb. The red line represents the transition we will be studying later in the lab (F = 3 → F' = 4).

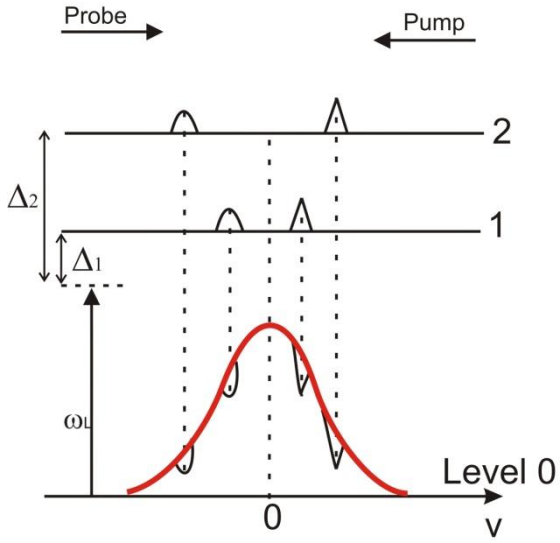
Figure Three



Saturated Absorption spectra associated with 4 Rb transitions show in figure two.

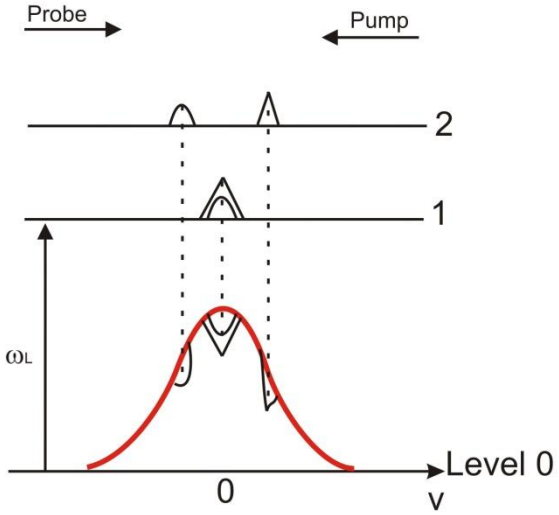
Crossover Resonances – Additional Peaks in Saturated Absorption Spectrum
Example: 2 transitions sharing a common lower state

1. $\omega_L < \omega_{01}$
2. $\omega_L < \omega_{02}$



- probe absorption is clearly unperturbed by pump on both 0→1 and 0 → 2 transitions

3. $\omega_L = \omega_{01}$ (Resonance condition for 0 – 1 transition) ($\Delta_1 = 0$)

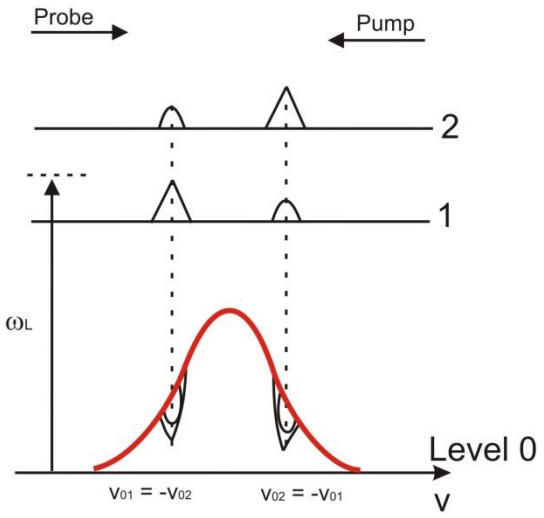


$$\frac{v_{01}}{c} = \frac{\omega_L - \omega_{01}}{\omega_L} = \frac{\Delta}{\omega_L}$$

- pump-probe interact with the same velocity class (v = 0) on the 0 – 1 transition

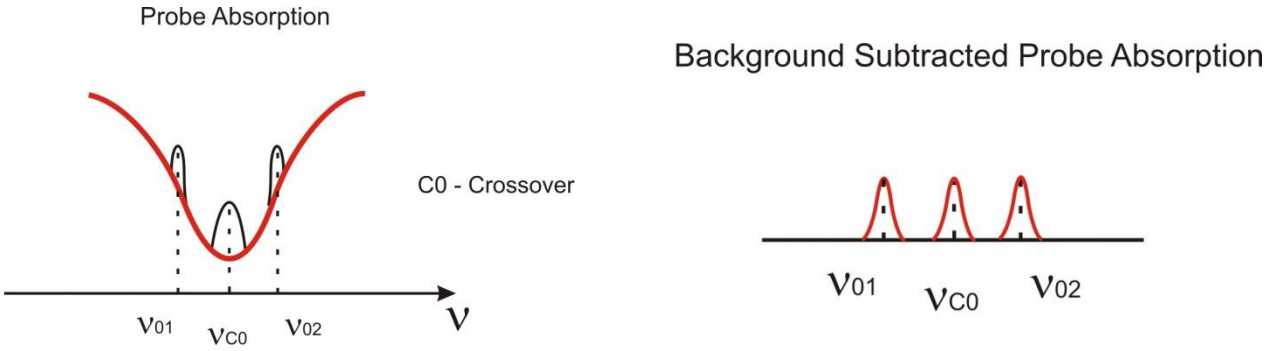
Note that pump and probe will also interact with v < 0 velocity class on the 0 – 2 transition if $\Delta_2 = 0$

4. $\omega_L = \frac{\omega_{01} + \omega_{02}}{2}$ (Laser tuned midway between 0 – 1 and 0 – 2 transitions)



- velocity group pumped on one transition is probed on other transition
- note scale of graph, there is no v = 0
- crossover transitions do not correspond to v = 0 group

Spectrum of Probe Absorption



- hole due to pump on 0-1 reduces probe absorption on 0-2
- hole due to pump on 0-2 reduces probe absorption on 0-1

Overview of Diode Laser Experiments

1. Zeeman shifts
   - F = 3 to F′ = 4 transition has seven degenerate transitions in zero field
   - Contribution of magnetic sublevels
   - Optical pumping during scan
2. Laser Stabilization/Lockin
   - Scan laser over F = 3 to F′ = 4 transition
   - Lock to crossover peak
3. Absorption/Emission Spectroscopy / EOM
   - Absorption
   - Fluorescence
   - Identify peaks in ^{85}Rb and ^{87}Rb and identify sidebands
4. Fabry Perot/ Index of Refraction
   - Laser linewidth
   - Interference signal within Doppler profile