Longitudinal Attenuation Measurement

- No independent fractional ionization measurement
Which States are involved in the transitions?

• 5s is ground state

• 780 nm: 5s->5p3/2  (also for 795 5s-> 5p1/2, but we don’t really use this transition)

• 421.55nm, 420.18 nm: 5s-> 6p ½, 3/2

• Each of these wavelengths will have resonances in the absorption cross-section.
• If we have a line laser that is significantly narrower than the doppler broadened resonances lines ~700 MHz, and laser is typically sub MHz then we can use the amount of absorption to determine what the ground state population’s fraction is
Absorption

Calculation of the vapor density from the transmitted intensity in the linear absorption regime:

Lambert-Beer: \[ I_{\text{trans}} = I_0 \cdot e^{-\alpha(\omega, N) \cdot L} \]

\[ \alpha(\omega, N) \approx \alpha(\omega) \cdot N \]

Ionization rate:

\[
\frac{N_{\text{vapor}} - N_{\text{plasma}}}{N_{\text{vapor}} - N_{\text{residual}}} = \frac{\ln(I_{\text{plasma}}/I_{\text{vapor}})}{\ln(I_{\text{residual}}/I_{\text{vapor}})} = 1 - \frac{N_{\text{plasma}}}{N_{\text{vapor}}}
\]

where \( N_{\text{vapor}}, N_{\text{plasma}}, N_{\text{residual}} \) are the (ground state) atomic densities in the different media.

These calculations reflect a regime in which we are significantly detuned away from resonance so that we can do the linear expansion of \( \alpha(\omega, N) \). This is easier to deal with in terms of fraction but insensitive if the residual atomic Rb is at the percent level.

In principle, if we know the absorption well, we can go into the resonance and get a very sensitive measurement depending on the nL product and the cross section. Need to be a bit careful doing this because hyperfine structures can emerge.
Marginal Results Using 780nm

- Aperture issues
- Saw some interesting focusing effects
- Beam overlap issues

![Diagrams showing results in Rb vapor and residual Rb vapor with and without TiSa.](Image)
Why use a blue laser?

• Isolation: Filter based isolation
  • Reflections of ionizing laser created a background with the 780

• Coupling out in tunnel with bleed at MP4, instead of in laser room helps aperture

• Smaller spot size for a given Rayleigh range:
  • Easier to fit in plasma column completely
Blue Laser Installed; turned on yesterday.

Power meter

Blue laser head on table

Rb reference cell

421.725 nm
Littrow ECDL

External Cavity Diode Laser using Littrow configuration.

Littrow configuration means that angle of incidence is angle of first order, so you get first order reflected back to the direction of input.

From Toptica Manual
Rest of today and beyond

- Search for 5s->6p state transition lines using Rb cell
- Request laser controller migration to TN (currently on GPN)
- Alignment aid installation likely first week of my run in April