Diode-Pumped Alkali Laser Kinetics

Anthony P. Rapp1, 2, Dr. Glen Perram1, Dr. Christopher Rice1, 3, Dr. Steven Fiorino1
1Department of Engineering Physics, 2Southwestern Ohio Council for Higher Education (SOCHE), 3Oak Ridge Institute of Science and Education

Abstract
Diode Pumped Alkali Lasers (DPAL) are a new concept to merge the high output of chemical lasers and the practicality of solid state lasers. By mixing an inert buffer gas (He, Ne, Ar, Xe) at different pressures and temperatures changing how alkali absorbs light, altering the power output and spectral shape of the laser. This experiment produces better insight of the alkali interaction with the buffer gas, and demonstrates spectral cross section and how it compares with current theories. By studying the spectral cross section of each collisional partner with rubidium, the efficiency of gain cell configurations can be optimized.

Pressure Broadening
•Collisions between atoms reduce lifetime of the upper state allowing a population inversion for lasing
•Pressure broadening depends on both pressure and temperature
•Broadening effect is typically described by a Lorentzian profile, but asymmetric line shapes have been observed.

Satellite
•Blue and red satellites have been observed in the absorbance spectrum.
•Peak wavelength depends on the polarizability of the buffer gas
•Higher polarizability leads to a shorter peak wavelength and more prominent peak
•The satellite location is used to better characterize details of the absorbance behavior of the system

Set Up
•McPherson Monochrometer
  •Grating 1200 groves, 500 nm blaze
•Burle C31034 Photomultiplier Tube
  •Converts photons into electric current
•Keithley Picoammeter
  •0.175 sec trigger
  •Measures converted electric current
•100W Ealing Broadband Light
•Creare Gas Recirculator System
  •Keeps Rb vapor and associated buffer gasses at steady temperatures and pressures
•Varian Model EX969996 Turbo Pump
  •Put system under vacuum

Results

Helium

Argon

Neon

Xenon

Analysis
A program was written to analyze the collected data from the cell. Shown are a few of the steps from moving raw data into our cross section plot.

The opaqueness due to PMT limitation and window transmission deterioration causes plateaus in the higher-temperature data. Spectral calibration is achieved using using known lines from a Krypton lamp.

The data is then taken piece by piece to produce the peaks and their widths. Using this method, we are able to accurately reproduce the absorption spectrum despite the limitations from our equipment.

Conclusion
This experiment produced more complete data regarding how the broadening and absorption of the alkali spectrum is dependent on temperature and pressure and collisional partner. This data, in addition to the better understanding of the behaviors, assists in the design of a more efficient diode-pumped alkali laser.

Also in our experiments, it can be clearly seen that the blue satellite predicted by the Anderson-Talman theory is indeed present in our data, and can be noticed to be red-shifting close to the peaks with increasing polarizability of the buffer gas. We also may note the change in shape of the blue satellite, as it changes from an extended slope into a distinct peak, with increasing polarizability.

We also see a rise of the red satellite in Xenon, also predicted but expected to be less prevalent than is seen. This is caused by a degeneracy in states, allowing two different potential curves for the D₂ lines.