**Include:**

* Goal of this chapter
* How to get concentration from light
* How the light travels
* How absorbance spectrum of gas is determined from measured intensity
* All sources of noise and how they are eliminated
* (Link to appendix for list of components) not necessary if not meant to be reproducible
* Wavenumber range and other limitations

**(Goal)**

The various the components and conditions of the measurement setup that influence the determination of the gas compounds and concentrations are explored. In order to understand how these components influence the eventual concentration, the path of light through the components is described starting from the quantum cascade laser (QCL) and ending at the CCD camera. For a more in depth analysis and reproducibility of the setup, refer to A. Reyes Reyes[REF].

**(concentration from light)**

In order to obtain information on the gas through spectroscopy, the interaction between light and matter needs to be established. The relation of the concentrations of the compounds in the gas to the light passing through is given by the Beer-Lambert law:

\begin{equation}  
I\_o (\lambda,C)= I\_i10^{-A(\lambda,C)

\end{equation}

with \begin{equation}

A(lambda,C) = \sum\_{c\_mol \in C,\epsilon\_mol(\lambda) \in \Epsilon(\lambda)} \epsilon\_mol(\lambda)\*c\_mol\*l$

\end{equation}

where $C$ and $\Epsilon(\lambda)$ denote the set of all concentrations and the set of all molar absorptivities respectively of the molecules in the gas.

The Beer-Lambert law states a relation between light with intensity $I\_i$ entering a gas, its absorbance $A(\lambda)$ by the gas, and its intensity $I\_o$ as it exits the gas. The absorbance is a function of the interaction length $l$ of the light with the gas, and the concentration $c\_mol$ and the molar absorptivity $\epsilon(\lambda)$ of the different molecules in the gas. The Beer-Lambert law shows that in the setup the interaction length and the intensity of the light going in and coming out of the gas must be measured.

**(travel path of light)**

To find the concentration of compounds within a gas the following spectroscopy setup is used:

[Picture of setup and diagram of setup]

[figure a: Picture of the quantum cascade laser spectroscopy setup as used for measuring.

Figure b: Diagram of the spectroscopy setup.]

By way of its construction the QCL emits different wavenumbers of light simultaneously. Since the CCD cameras used detect the intensity of the light without differentiating between the various waves