May 4th, 12:00 PM - 2:00 PM

Listening to Lasers: Photoacoustic Gas Sensing

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Listening to lasers: photo-acoustic gas sensing

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Introduction: Last summer at the behest and funding of a local company we endeavored to make a proof of principle gas sensor for CO_2. This sensor had the requisites of ppm to ppb sensing and of using the technique of photo-acoustic spectroscopy (PAS). PAS broken down into its components is literally using light (photons) to generate sound (acoustics) in such a way as to be selective to what you are looking at (~spectroscopy).

How this technique works: By taking a couple well known physical principles; 1) tubes of gas can and will resonate based upon the characteristics of the gas and its environment 2) chemicals in gaseous form (and in any form really) can absorb photons of certain energy levels and convert the absorbed energy into kinetic energy (motion.) Putting these two together we can make gas move in a known way and with some natural amplification.

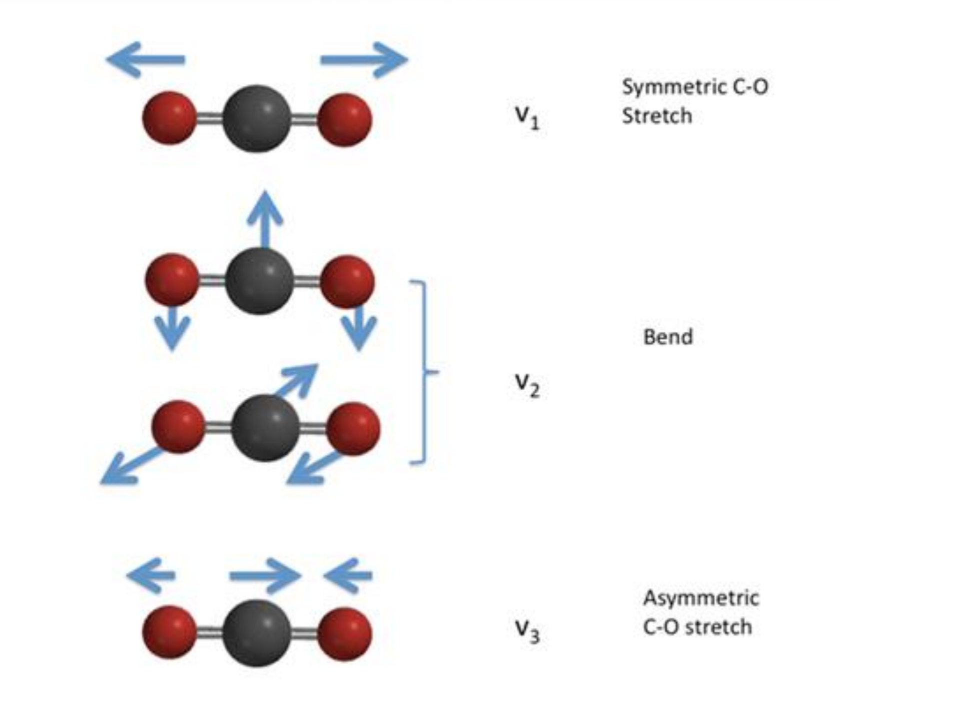
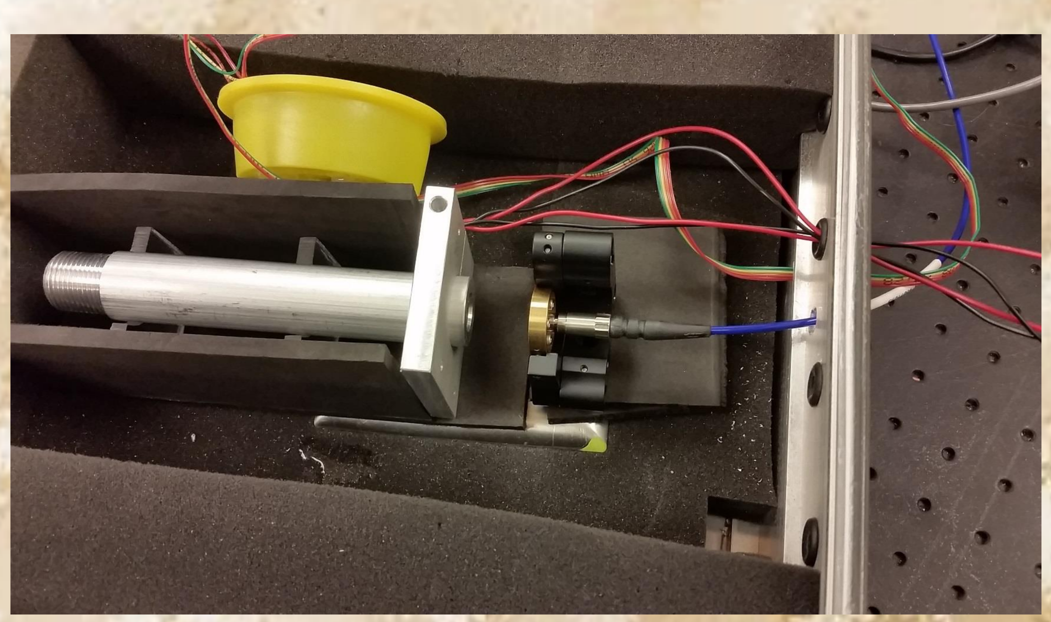


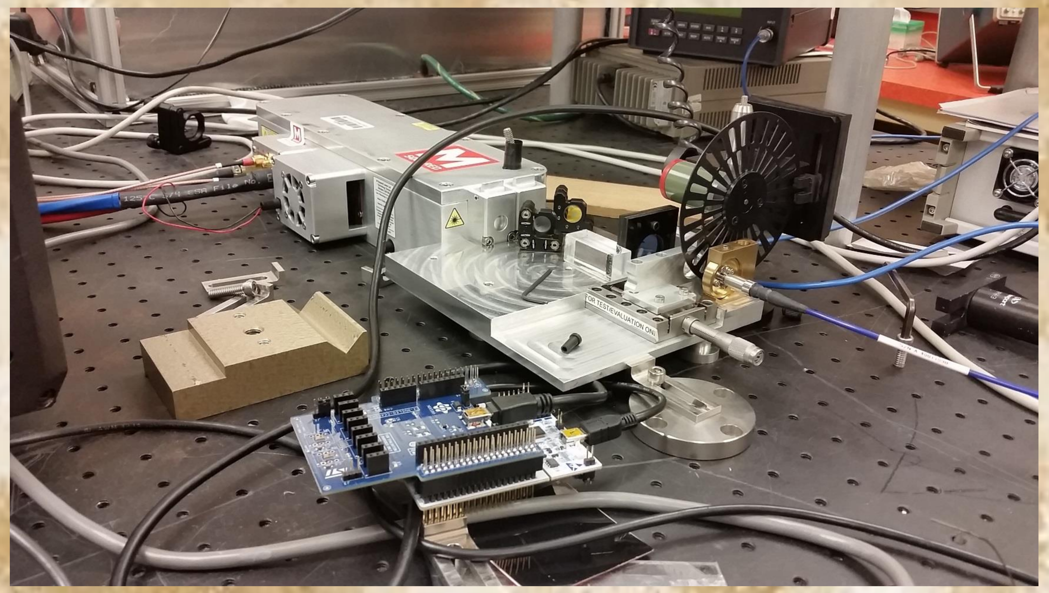
Fig. 1 Vibrational modes of CO_2

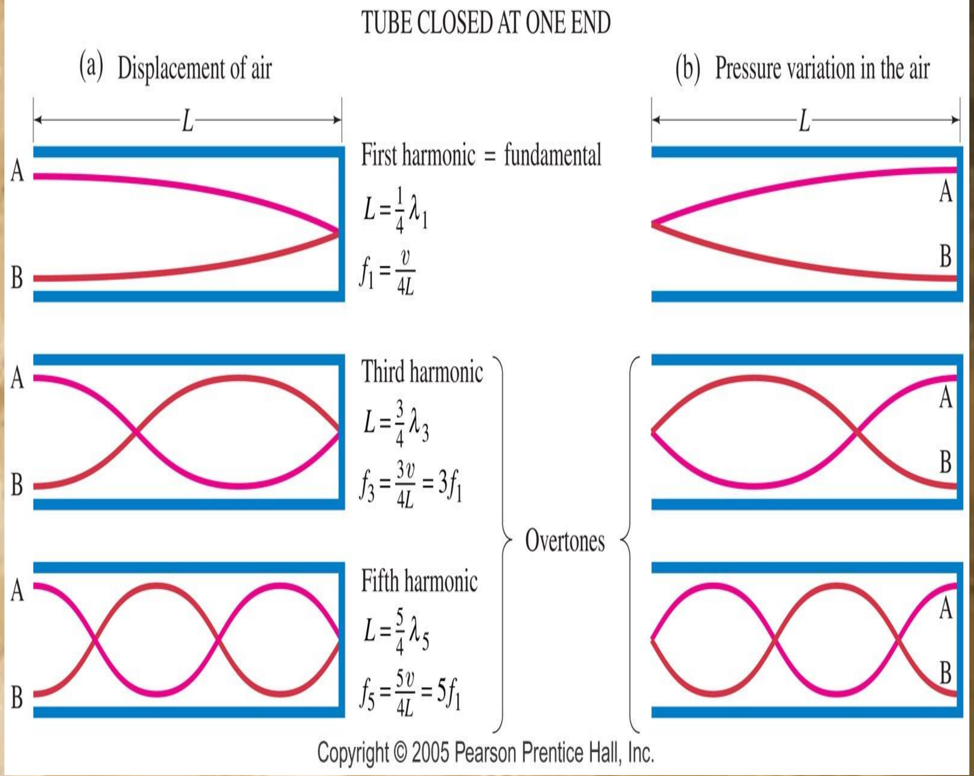
Image courtesy of UC Davis Chemwiki

$$PV = nRT \Longleftrightarrow PV = \frac{2}{3}N\left[\overline{\frac{1}{2}mv^2}\right]$$

Courtesy of hyperphysics.phy-astr.gsu.edu

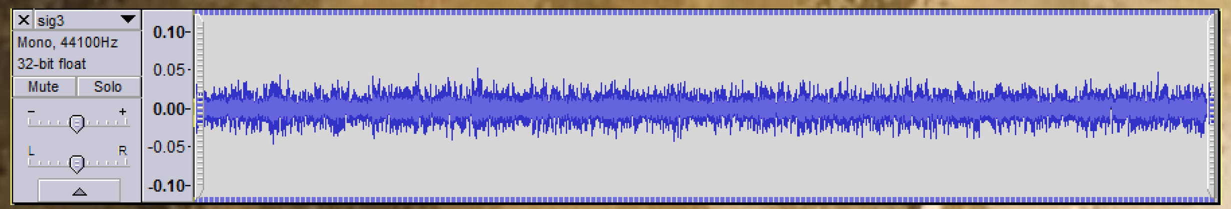


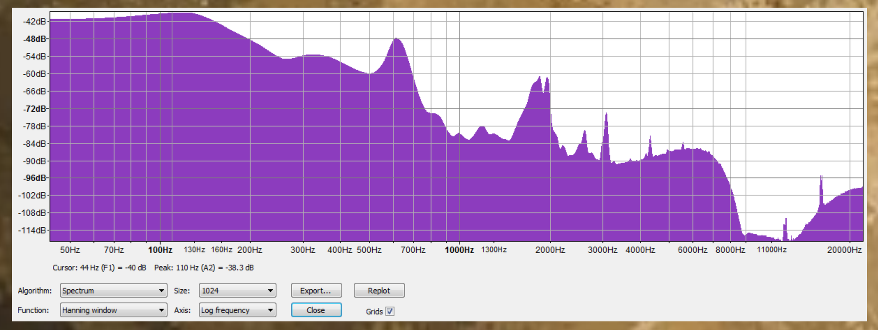




Courtesy of Pearson Prentice Hall

Future work: This project ended up using a very expensive laser as it was attempted with LEDs initially to no real success; what could be done is to use the concentration of multiple LED light sources for strongly absorptive lines of certain species. The use of a lock-in amplifier setup would also greatly help the project as this would completely absolve us of digital filtering and of the use of a chopper as we would have a current shutter operating at the tube resonance that would also initiate the window for detection. Really a new chamber designed for flow and the problems that come inherent in that choice should be manufactured as well.

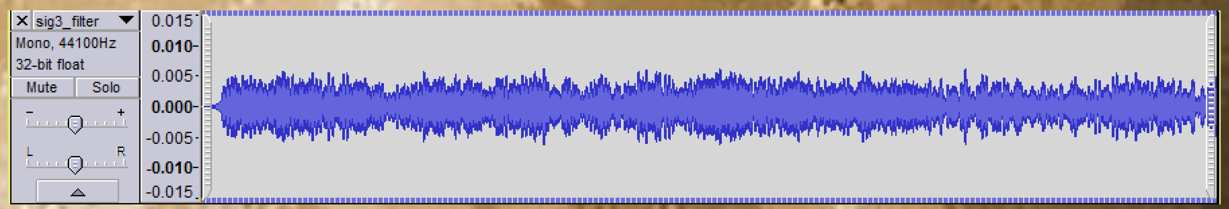


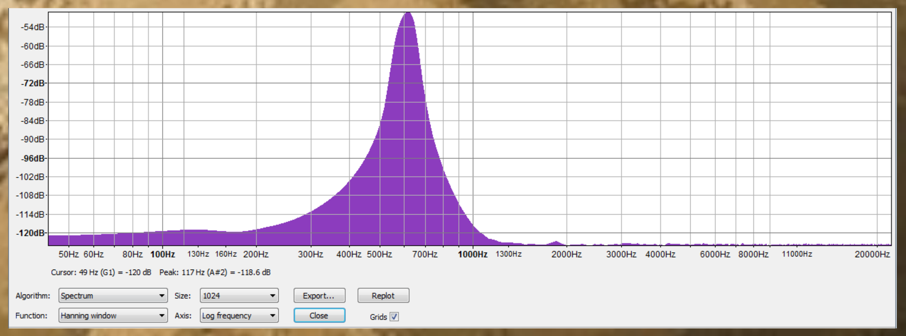


Clipped from Audacity.
Top: unfiltered raw recording
Bottom: Fourier transform of recording

File Name	Resonance (Hz)	Magnitude (dB)	Baseline average res (Hz)	Baseline average mag (dB)
BS1	606	-57.7	606.3333333	-58.4
BS2	606	-58.1	0.471404521	0.888819442
BS3	607	-59.4		
ON1	607	-57.8	On average res	On average mag
ON2	607	-57.7	607.3333333	-57.63333333
ON3	608	-57.4	0.471404521	0.169967317
SIG1	616	-48.5	Sig average res	Sig average mag
SIG2	615	-52.4	615.4	-49.7
SIG3	616	-49.3	0.8	1.588710169
SIG4	614	-50.4		
SIG5	616	-47.9		

BS, which is taken with the laser off but the chopper on, ON, which is the laser tuned to 4.004µm (non-absorptive to CO2) with the chopper on, and SIG, which is laser on at 4.231µm with chopper.





Clipped from Audacity.
Top: filtered raw recording
Bottom: Fourier transform of filtered file

Special thanks to: CID Bio-Science