Temperature profile determination for low pressure laminar methane flames from OH laser-induced fluorescence

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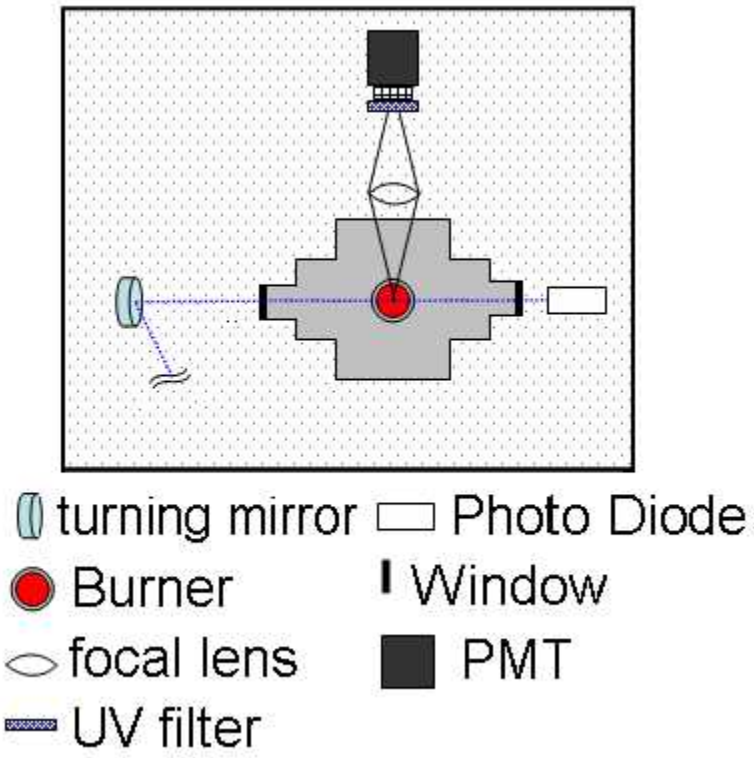
Temperature determination in Flames

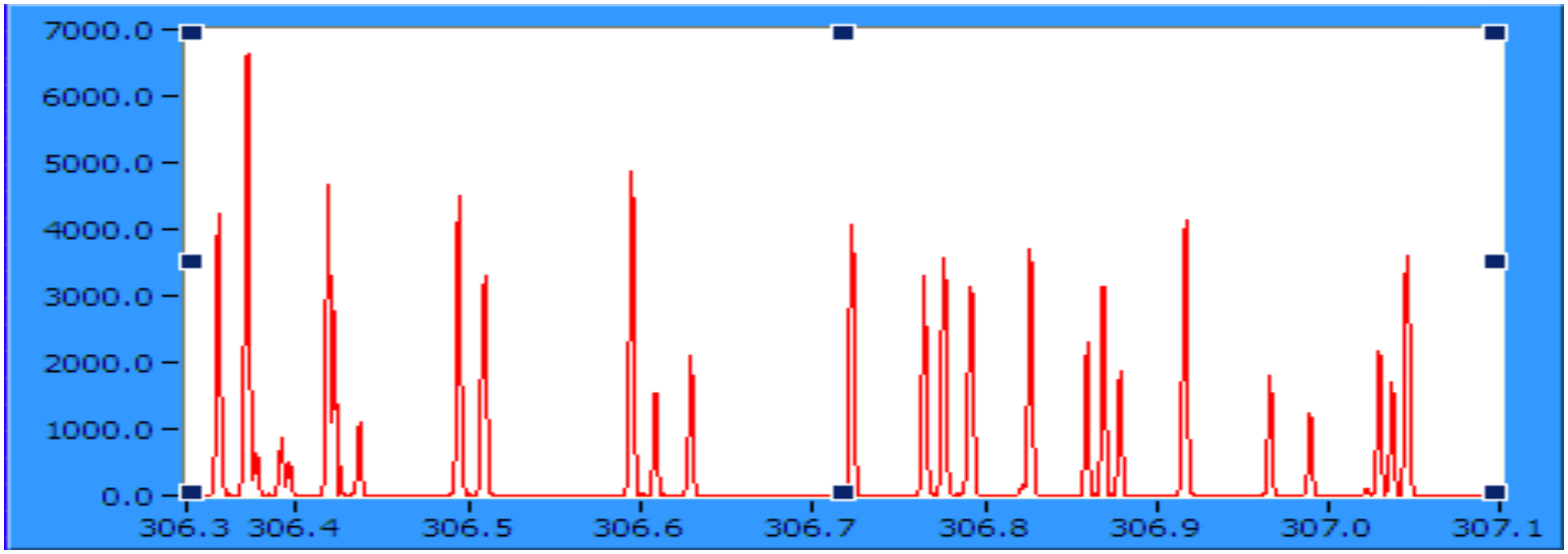
- Despite millennia of man's interaction with combustion, temperature determination in flames remains difficult.
- Techniques for measuring temperature
  - Thermocouple
  - Rayleigh Scattering
  - Coherent anti-Stokes Ramen Spectroscopy (CARS)
  - Laser-Induced Fluorescence
- Laser-Induced Fluorescence is the technique that we employ because it is non-invasive and gives accurate results.

Experimental setup

- The flames are stabilized on a water-cooled McKenna Burner
- The flame chamber is maintained at 25 Torr
- Tunable UV laser light is produced by frequency doubling the output of a Sirah Dye laser pumped by a 50 Hz Spectra Physics YAG laser.



LIF spectrum



- The dye laser is used to scan a nearly I nm wide spectrum.
- The strength of a transition depends on the population of the energy level and hence the temperature.
- The OH radical has been well studied making it easy to identify peaks and find good values for constants.

Data Analysis

- The Fluorescence signal is can be described by the equation

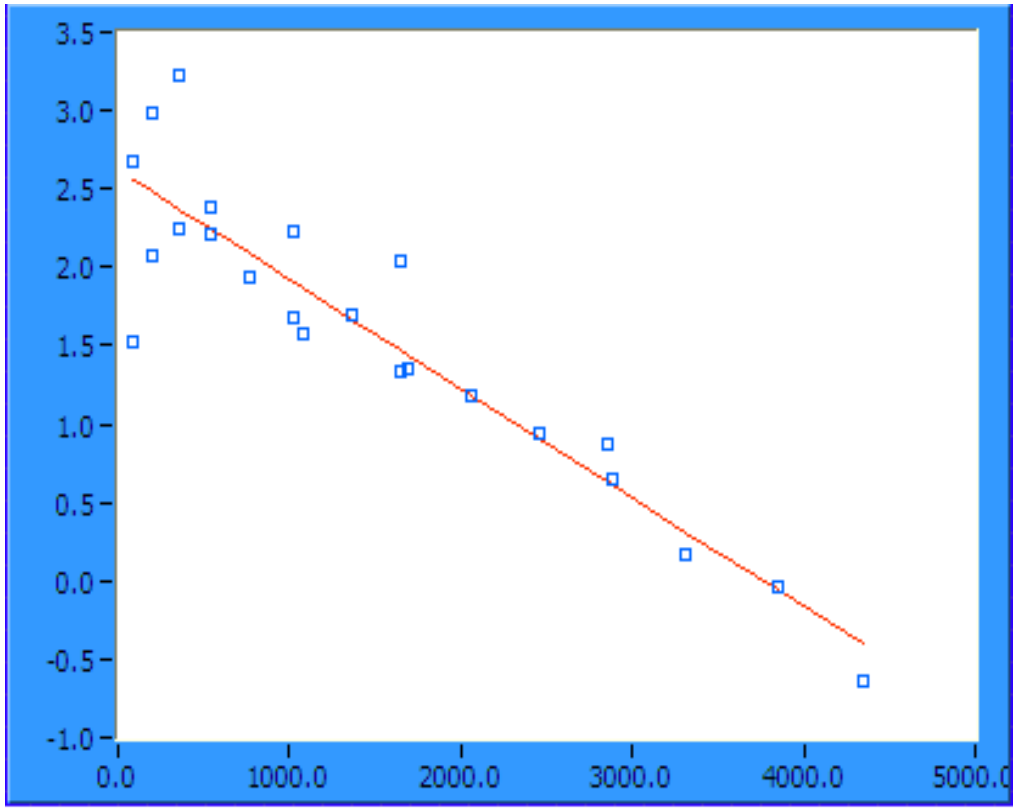
$$S = \frac{IC\eta BN(2J''+1)}{Z}\exp\left[\frac{-E_{Rot}}{kT}\right]$$

Where I is the Laser intensity, C is an experimental factor, η is the quantum yield, B is the emission coefficient, J is the quantum number, Z is the partition function, E_{Rot} is the rotational energy, k is Boltzmann's constant and T is the temperature.

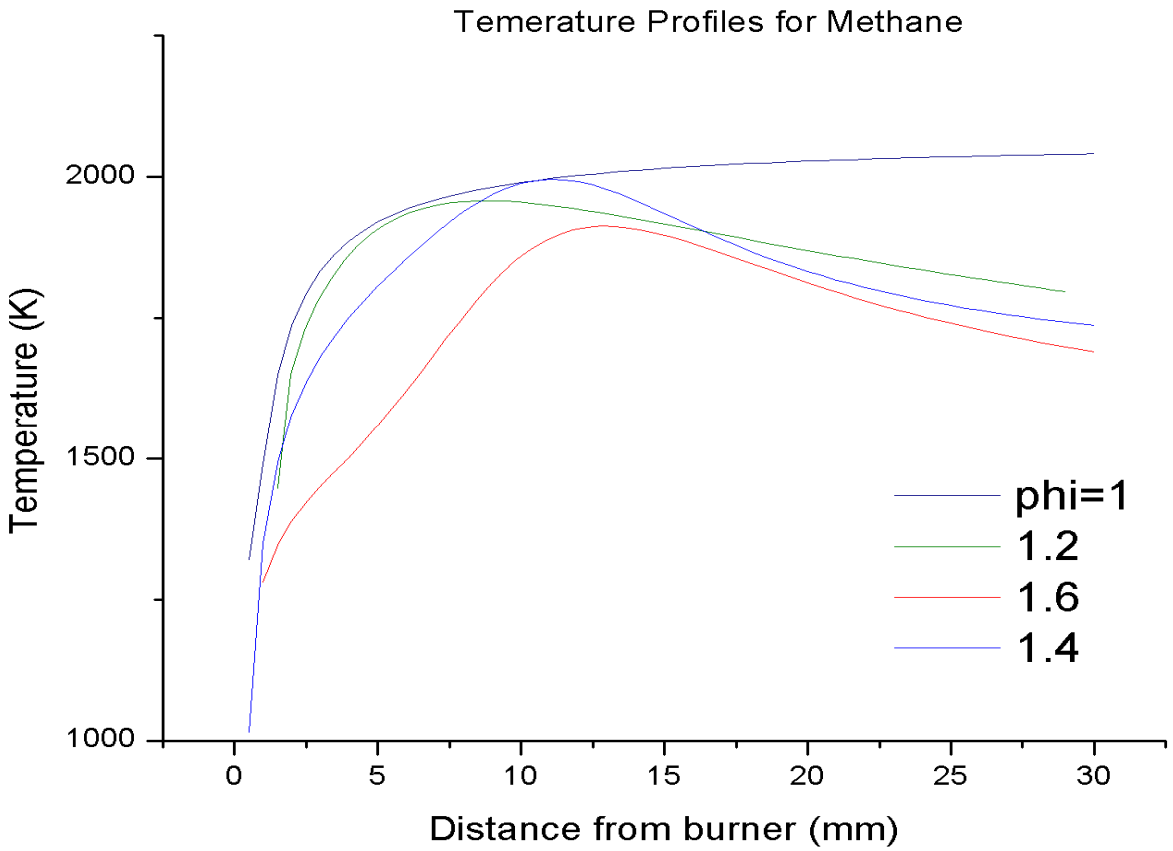
Data Analysis 2 - Boltzmann Plot

- The previous equation can be rearranged and plotted semi-log.
- A least squares line is drawn through the data and the temperature is found according to the equation

$$T = \frac{-1}{k(slope)}$$



Temperature profiles



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Conclusion

- The profiles that we have measured support those already published for low pressure methane flames.
- Laser OH laser induced Fluorescence is an excellent way to be able to measure flame temperature.
  - The major limitation of the method are that at the burner surface the concentration of OH is very low.
- As a result a the next planned experiments will include spiking the flames with NO. This should make temperature measurements closer to the burner possible.