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Quantitative Analysis of NH_2* in Premixed Ammonia-Air Flames

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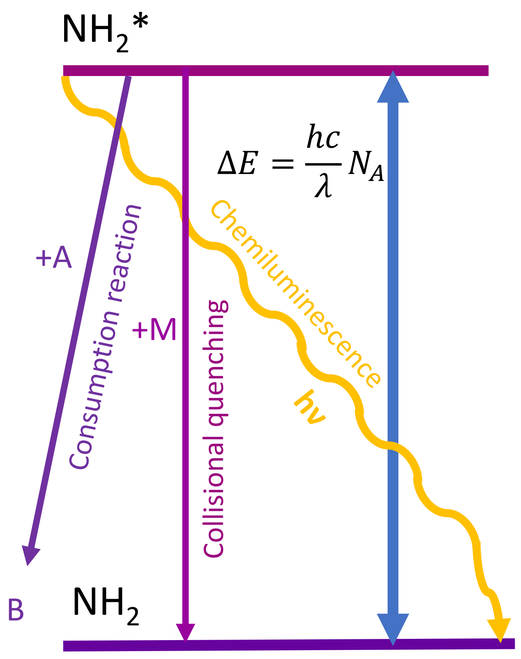
The interest in studying ammonia flames arises from the need to curb carbon emissions and to solve the energy crisis arising from the depletion of fossil reserves.

Why chemiluminescence?

- A cheap and non-intrusive diagnostic tool
- It provides various information on the combustion process, like assessing flame ratio and understanding flame topology.

Why NH_2* chemiluminescence?

- NH_2* chemiluminescence is used to determine the position of the maximum HRR in premixed ammonia-air flames.
- The relative intensity of NH_2* can give information on NOx formation



$$\Delta E = \frac{hc}{\lambda} N_A$$

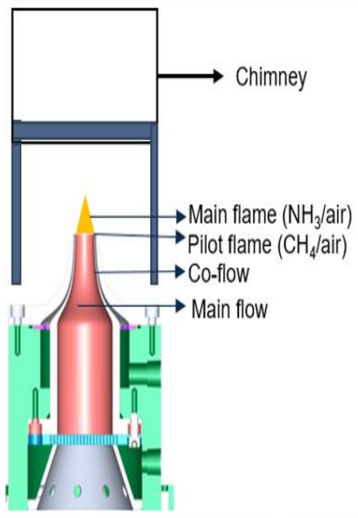
Why quantitative analysis?

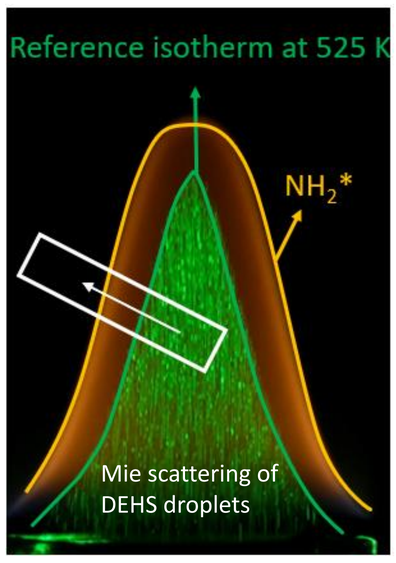
Possibility to have reference data for the chemiluminescent part of the species to model the total excited species.

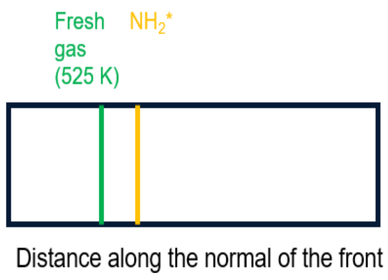
Procedure

- NH_2* chemiluminescence data at 632 nm for ambient conditions.
- Calibration to quantify the data.

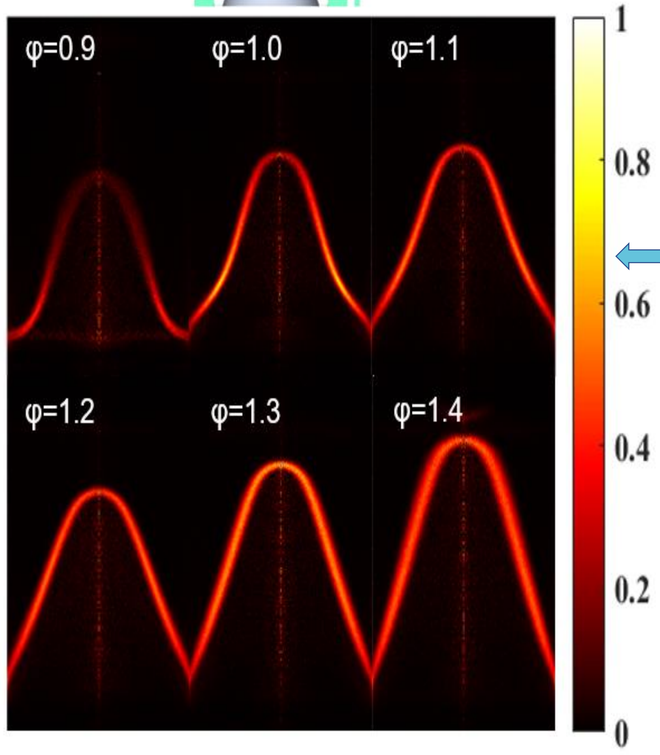
Chemiluminescence set-up







Determining the position of NH_2* within the flame

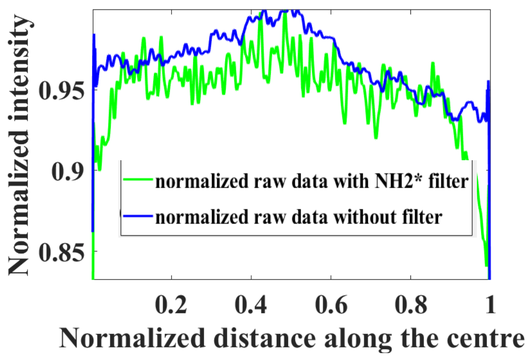


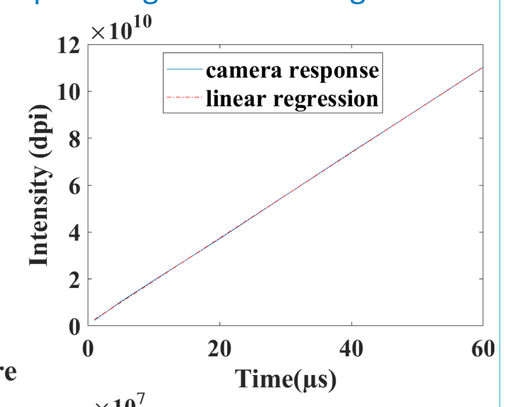
Normalized NH_2* distribution along the flame for different φ

Calibration process

Step 1: Optics Calibration

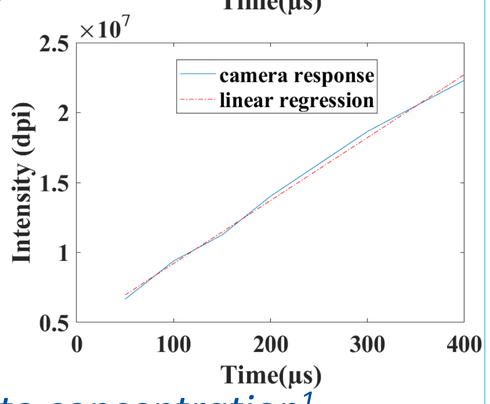
NH_2* filter response and camera response against a fixed light source





Step 2: Tungsten lamp calibration

- Irradiation data as a function of wavelength
- Filter and camera response against the tungsten lamp



Step 3: Converting intensity to concentration[1]

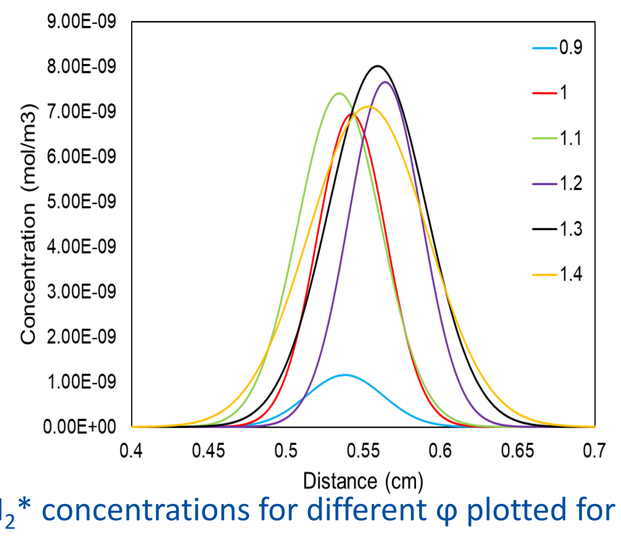
$$\frac{I_{species,Abel}}{I_c} = \frac{\frac{1}{4\pi}[species]N_A\eta_\lambda\tau_1\Delta t_1}{\int_{\lambda 1}^{\lambda 2}\frac{S_{c(\lambda)}}{h\nu}\eta_\lambda d\lambda\tau_2\Delta t_2}$$

Step 4: Adapting to the configuration

- Irradiation values were provided at a distance of 50 cm
- Values adapted to fit the experimental set-up distance

Results

- On moving from fresh gases towards burnt gases, NH_2* profiles for a low stretch can be plotted.
- It is seen that the thickness of NH_2* increases with the equivalence ratio.
- Preferential diffusion of lighter species towards the base of the flame is noted for leaner flames.
- Future work includes accommodating these species in any existing chemical kinetic schemes.



NH_2* concentrations for different φ plotted for minimum stretch values

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Support from the CAPRYSSES project (ANR-11-LABX-006-01) funded by the PIA (Programme d'Investissement d'Avenir) is gratefully acknowledged.

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Reference

[1]Y. Liu, J. Tan, M. Wan, L. Zhang, X. Yao, Quantitative measurement of OH* and CH* chemiluminescence in jet diffusion flames, ACS Omega, (2020), 15922–30