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Quantitative Analysis of NH_2^* in Premixed Ammonia-Air Flames

Alka KARAN^{1,||}, Guillaume DAYMA^{1,||}, Christian CHAUVEAU^{||}, Fabien HALTER^{1,||}

¹Université d'Orléans, Chateau de la Source, 45100 Orléans, France

^{||}CNRS – ICARE, 1C Avenue de la Recherche Scientifique, 45071 Orléans Cedex 2, France

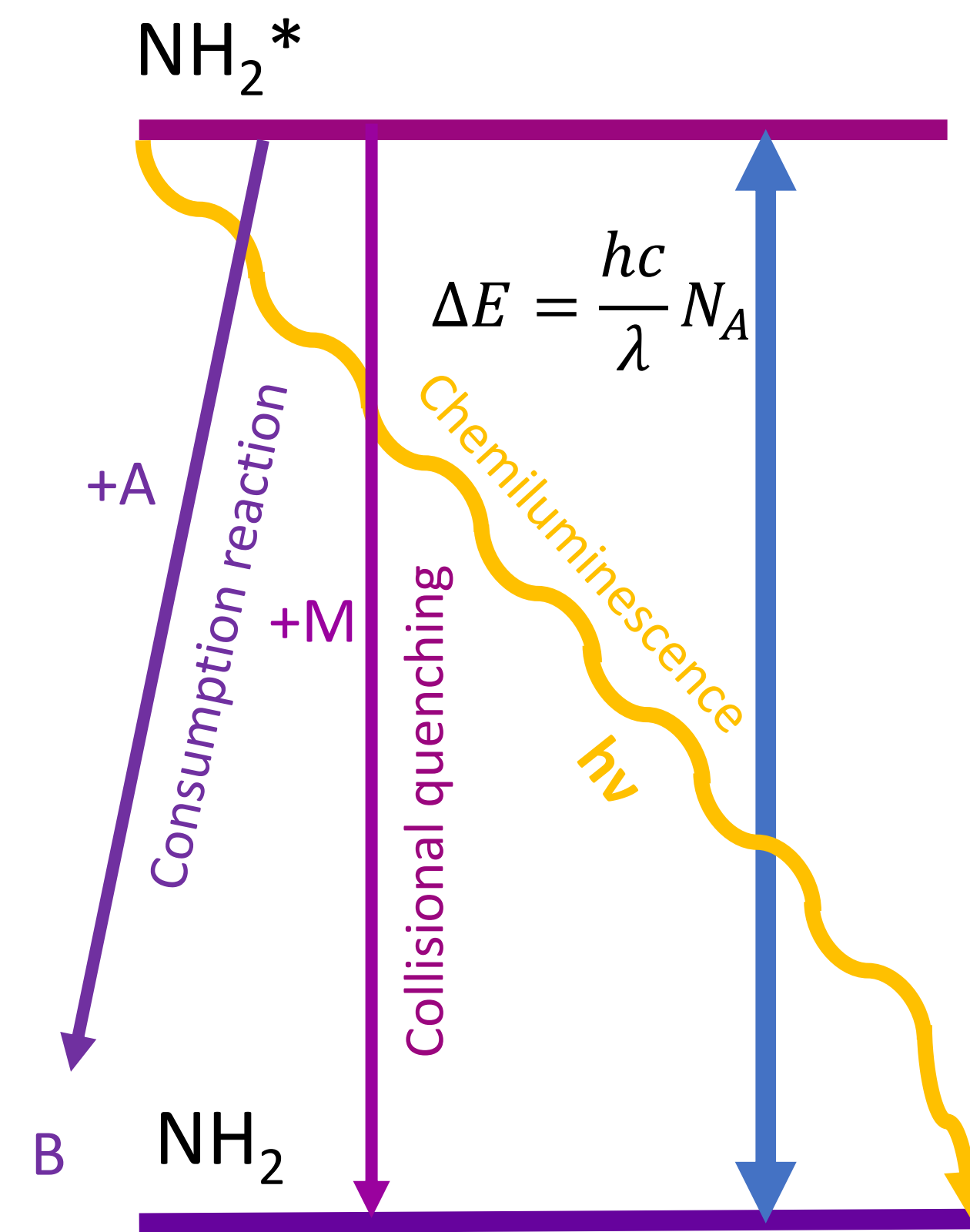
The interest in studying ammonia flames arises from the need to curb carbon emissions and to solve the energy crisis arising from the depletion of fossil reserves.

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



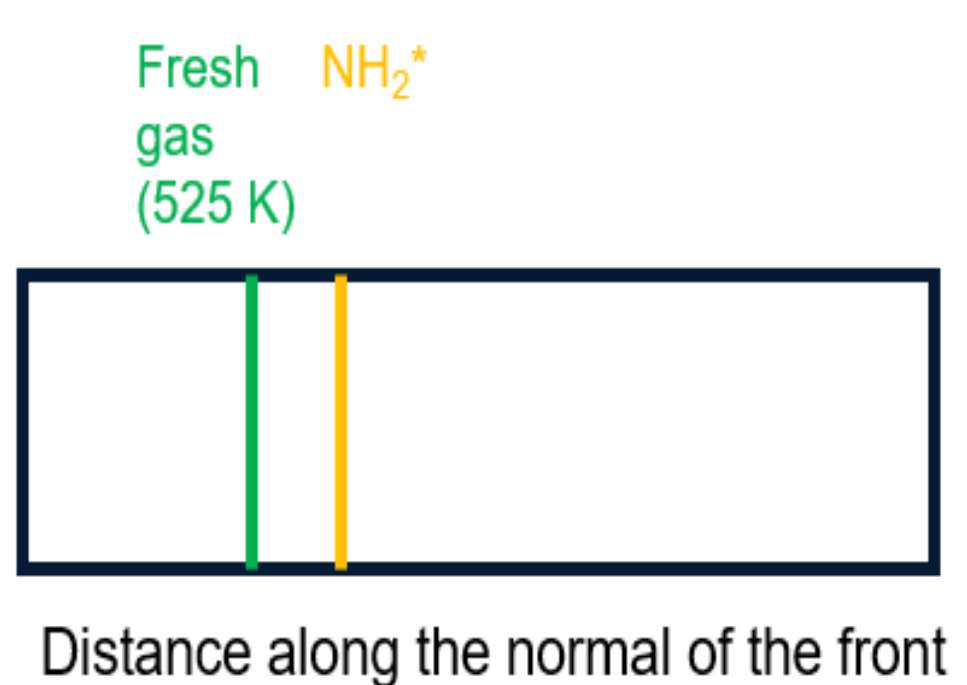
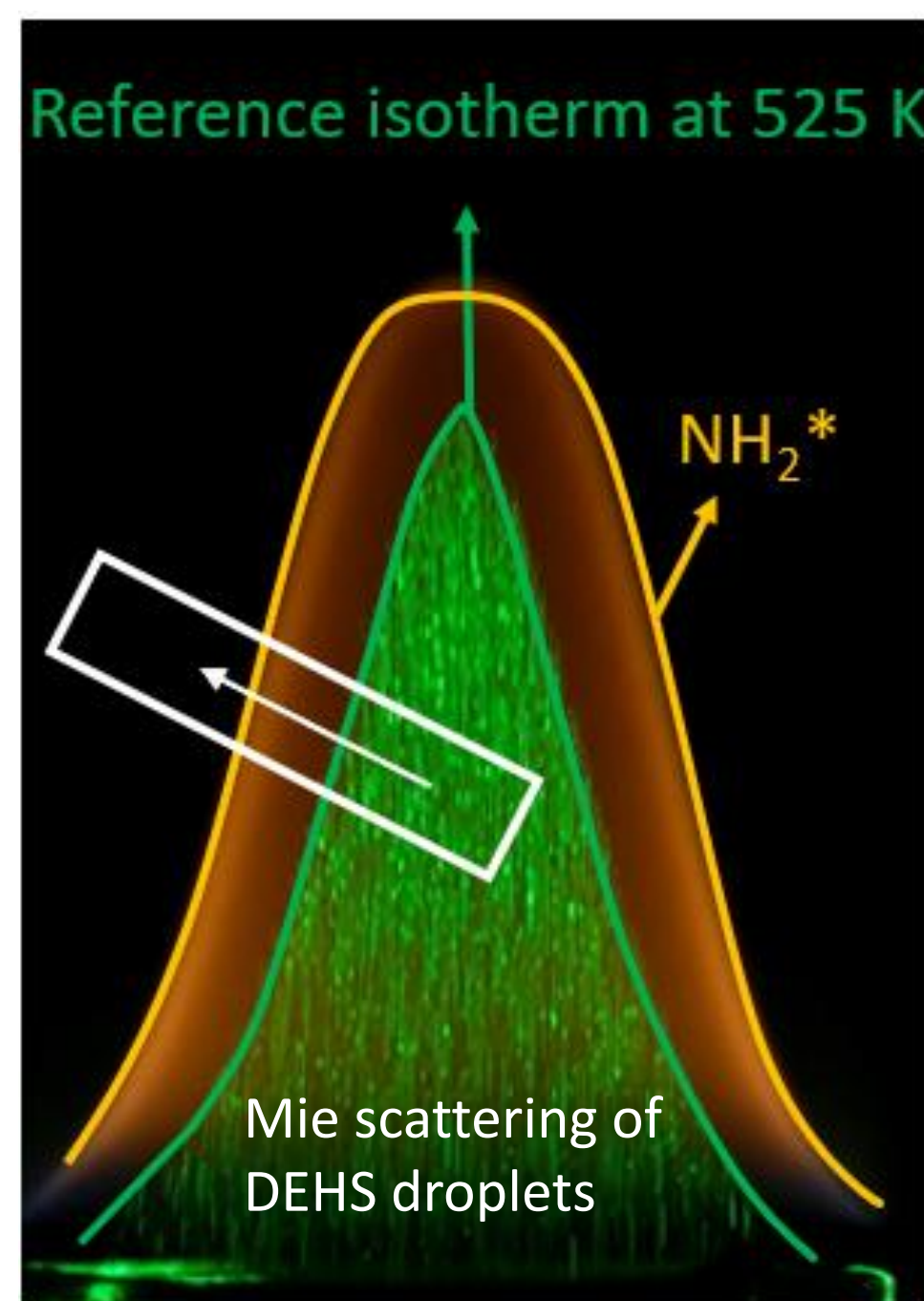
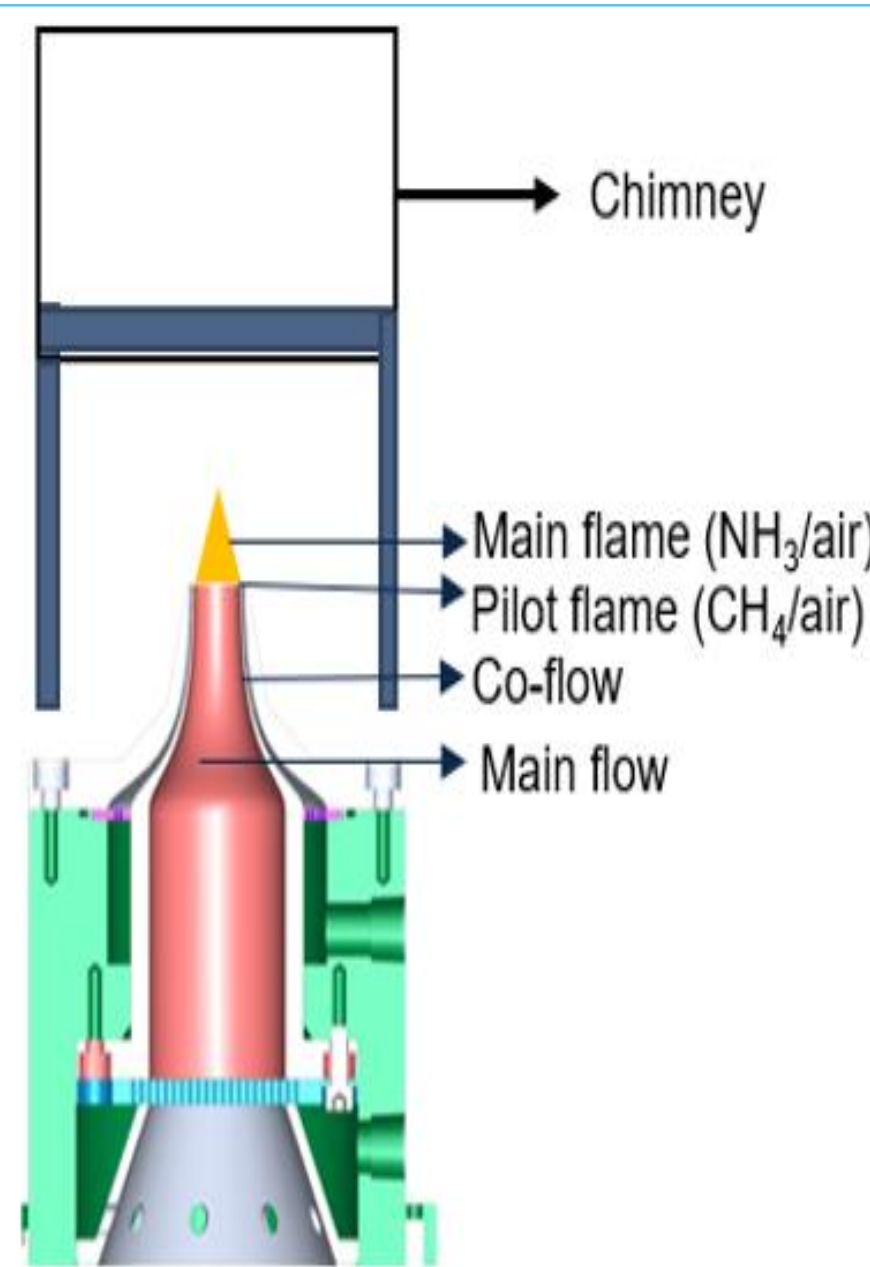
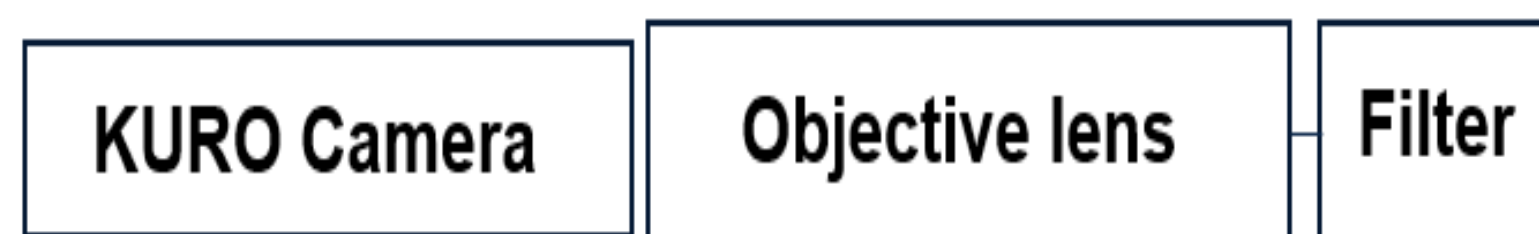
Why quantitative analysis?

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

Procedure

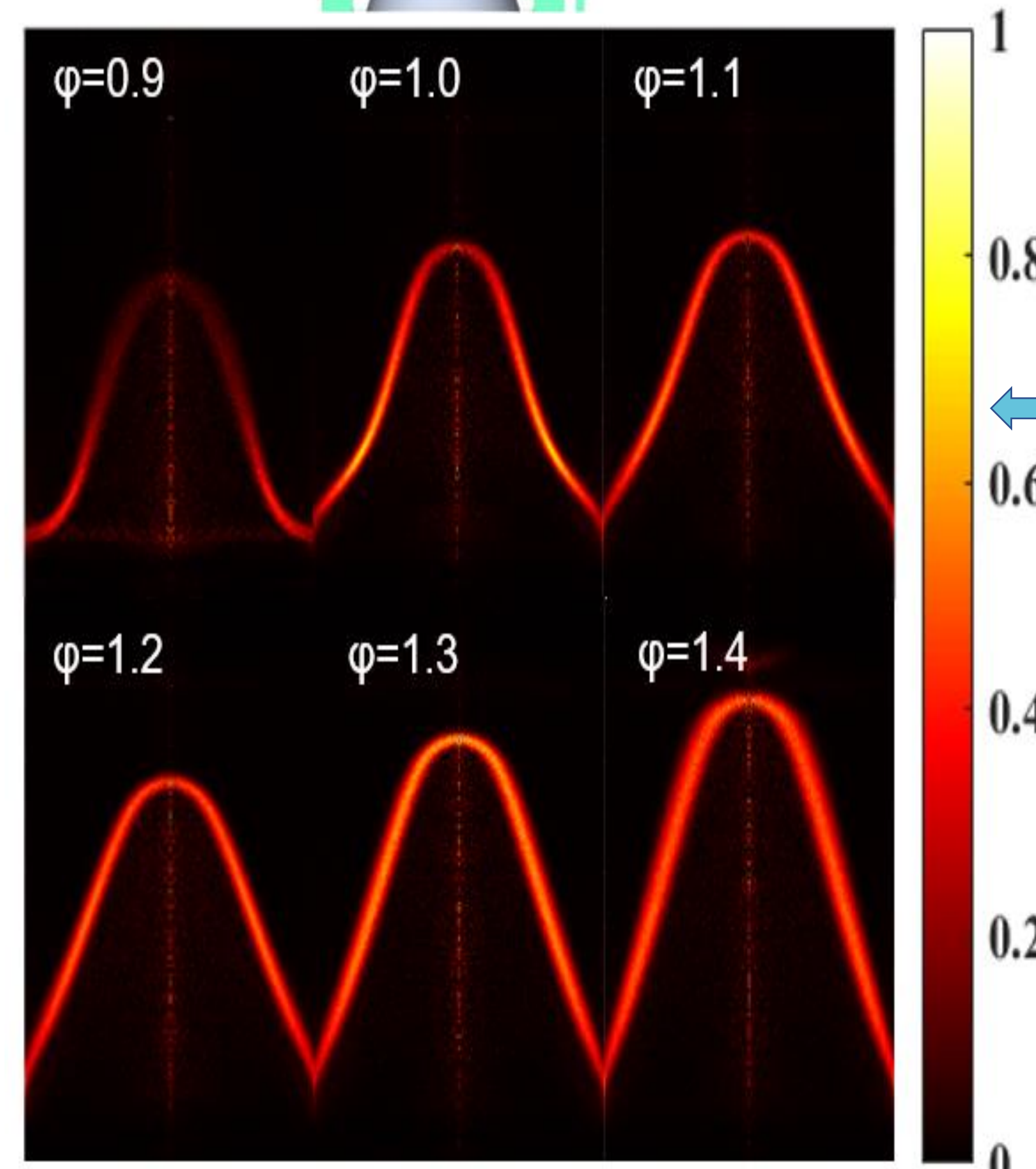
- NH_2^* chemiluminescence data at 632 nm for ambient conditions.
- Calibration to quantify the data.

Chemiluminescence set-up



Distance along the normal of the front

Determining the position of NH_2^* within the flame

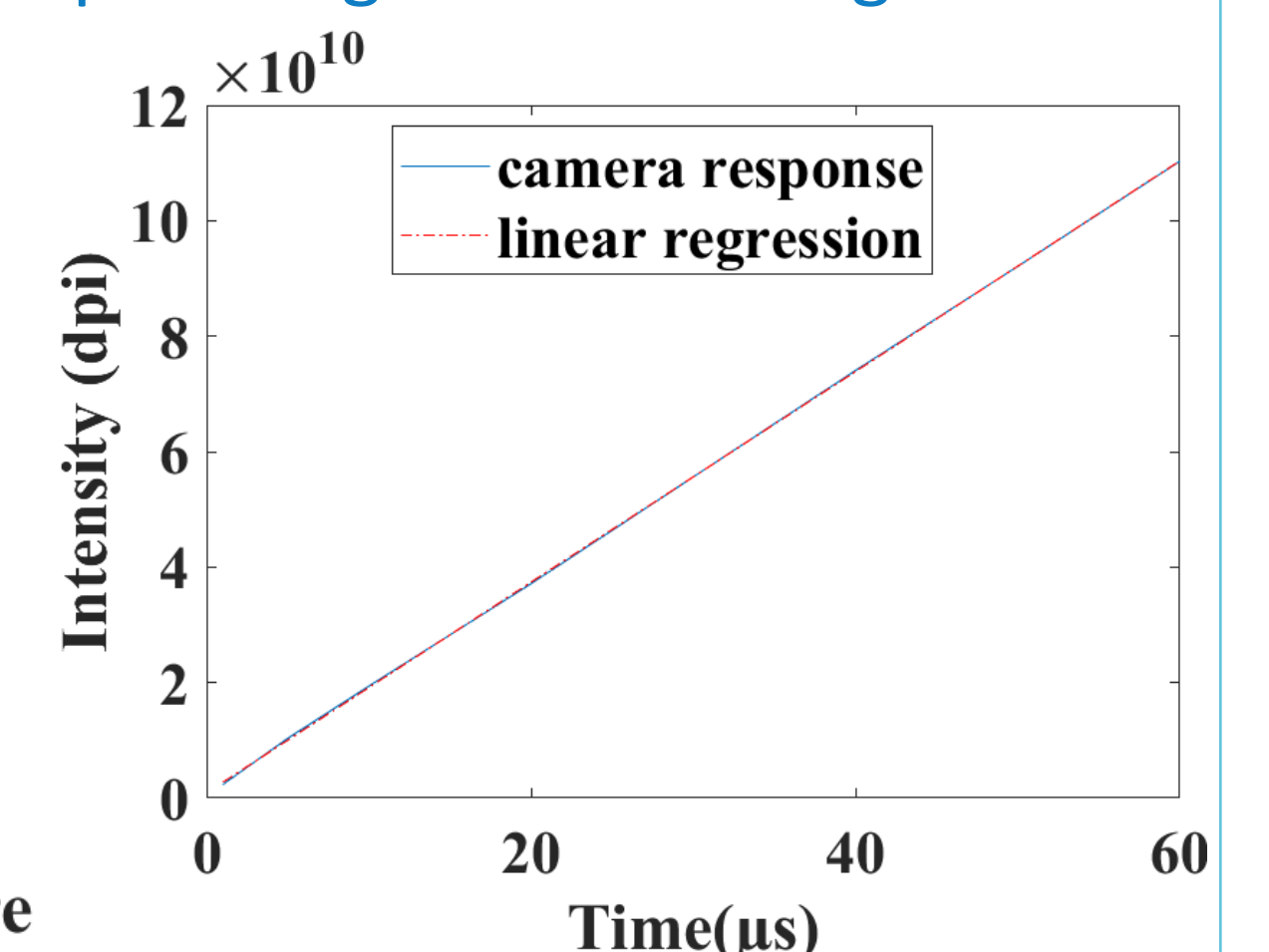
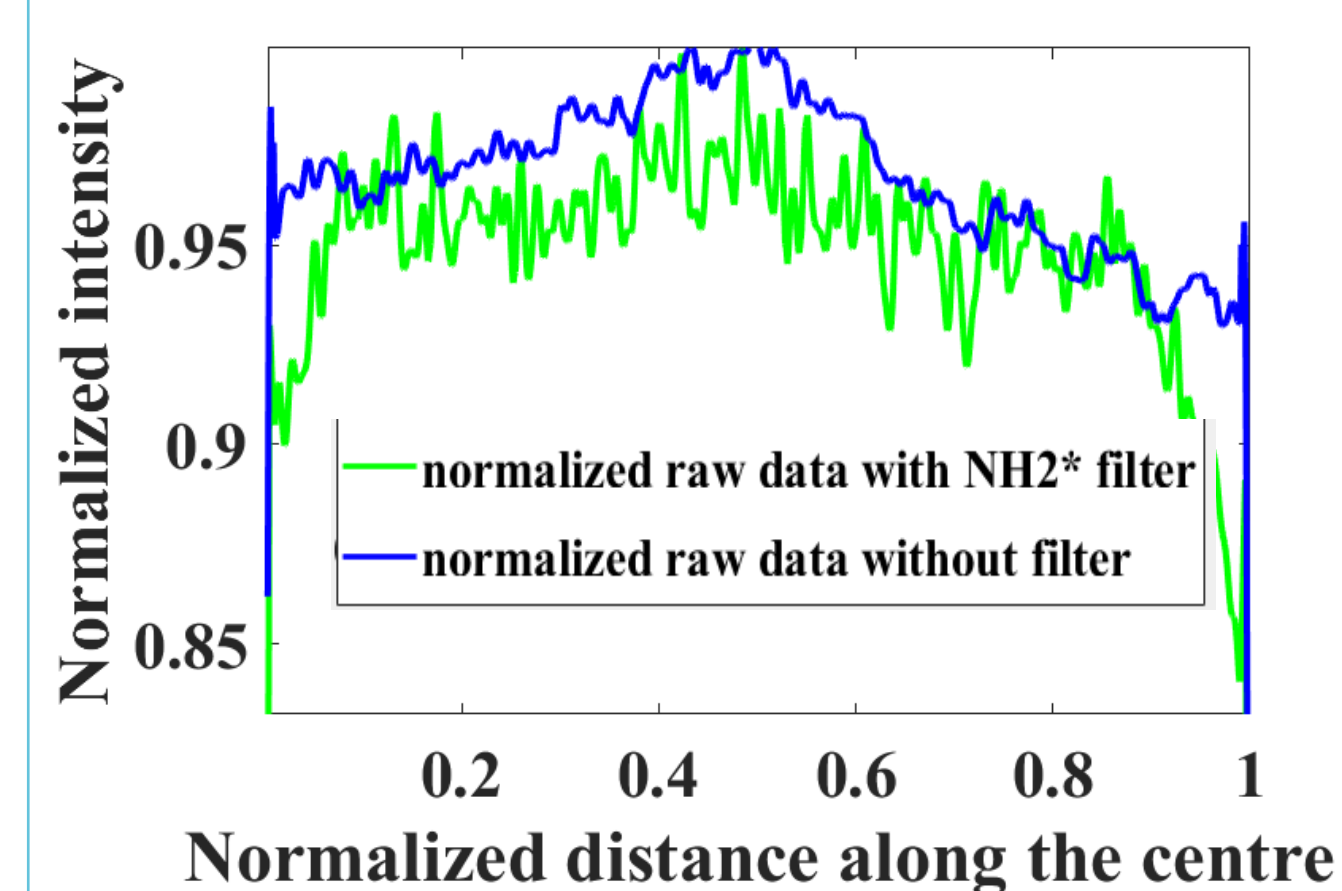


Normalized NH_2^* distribution along the flame for different ϕ

Calibration process

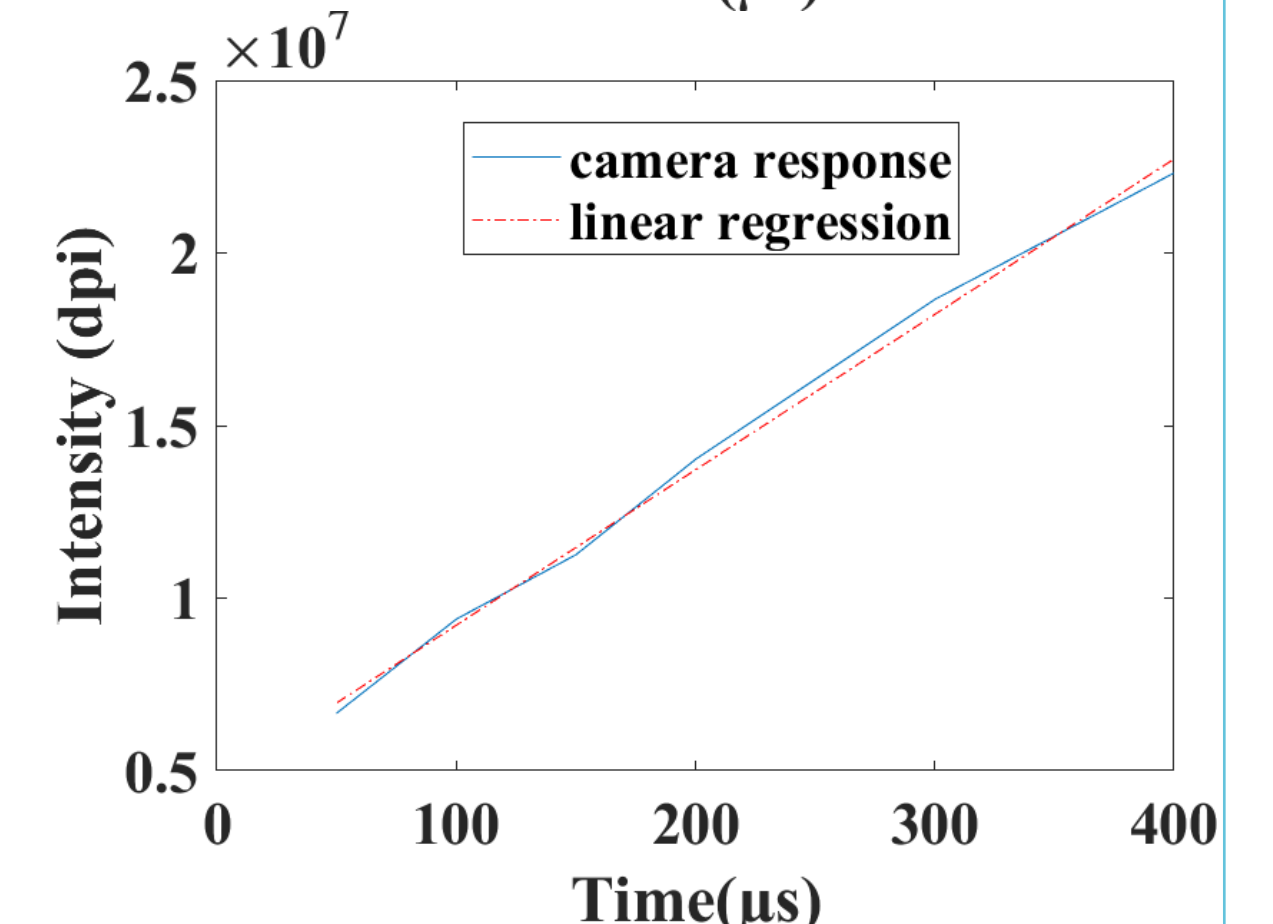
Step 1: Optics Calibration

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 concentration¹

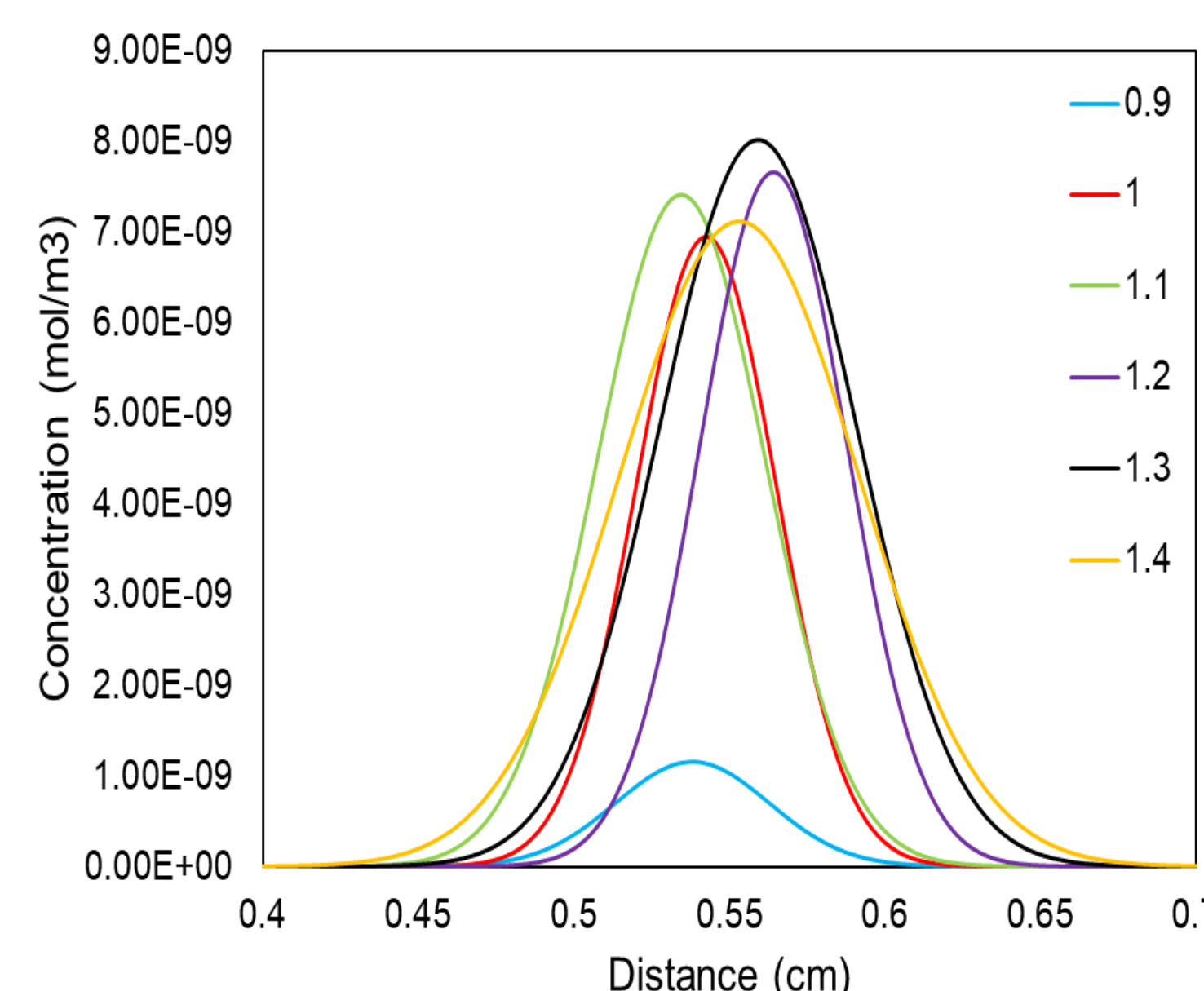
$$\frac{I_{\text{species, Abel}}}{I_c} = \frac{1}{4\pi} \frac{[\text{species}] N_A \eta_\lambda \tau_1 \Delta t_1}{\int_{\lambda_1}^{\lambda_2} \frac{S_c(\lambda)}{h\nu} \eta_\lambda d\lambda \tau_2 \Delta t_2}$$

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

Acknowledgement

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

ICARE-CNRS and Université d'Orléans are acknowledged as well.

Reference

¹Y. 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



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