

Background

- The LOX- H₂ system is widely used in rocket propulsion due to its high performance
- In rocket applications, the H₂ typically vaporizes, while the O₂ remains liquid upon injection, thus the problem of the combustion of liquid oxygen droplets in gaseous hydrogen is of fundamental interest

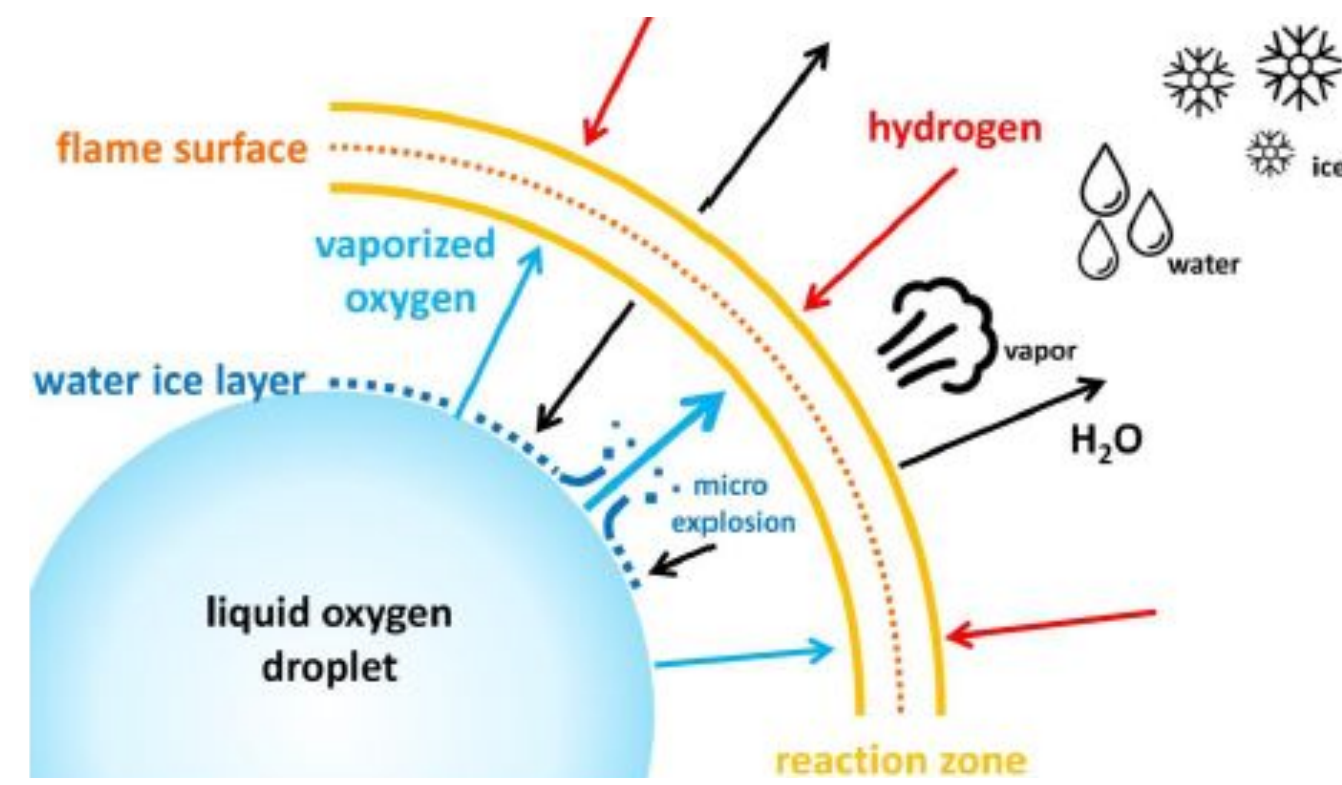


Fig. 1: Physical scenario.

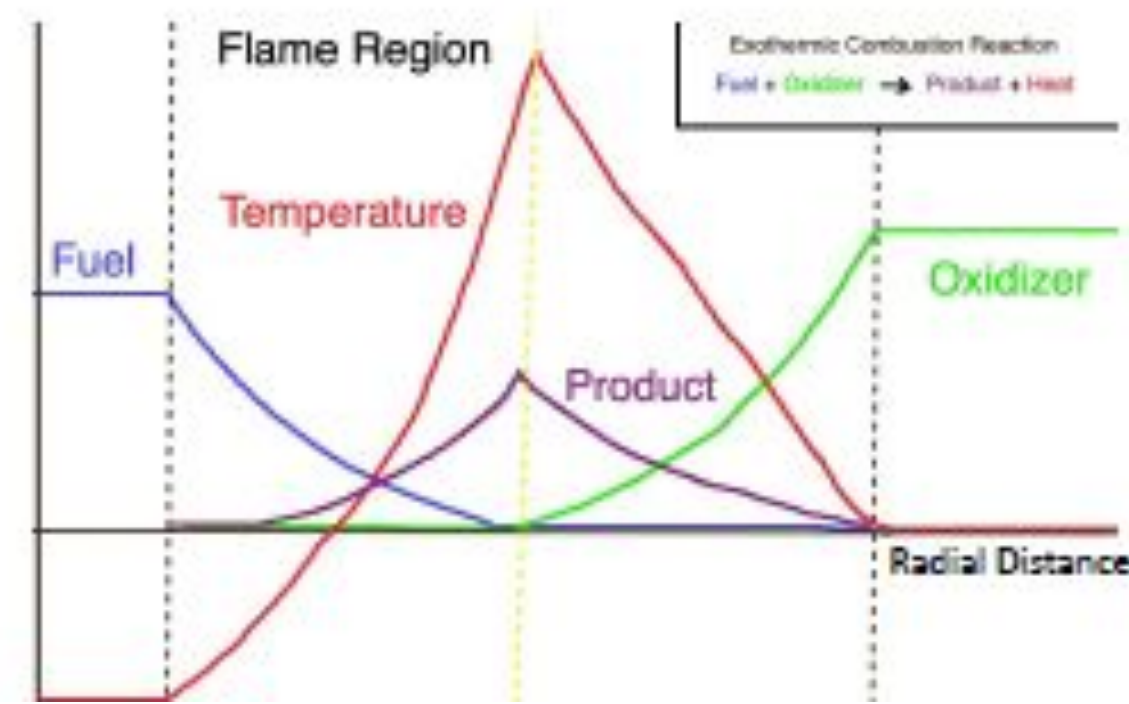


Fig. 2: Overview of Flame Geometry

Ongoing numerical simulations

- New numerical modelling approach:** Transient energy and mass conservation equations in both liquid and gas phases, accounting for variable thermophysical properties. Equations are solved using an implicit backward differentiation method within the finite difference method
- Model validated for n-heptane droplet evaporation in air, currently the code is being adapted for the LOX - H₂ case

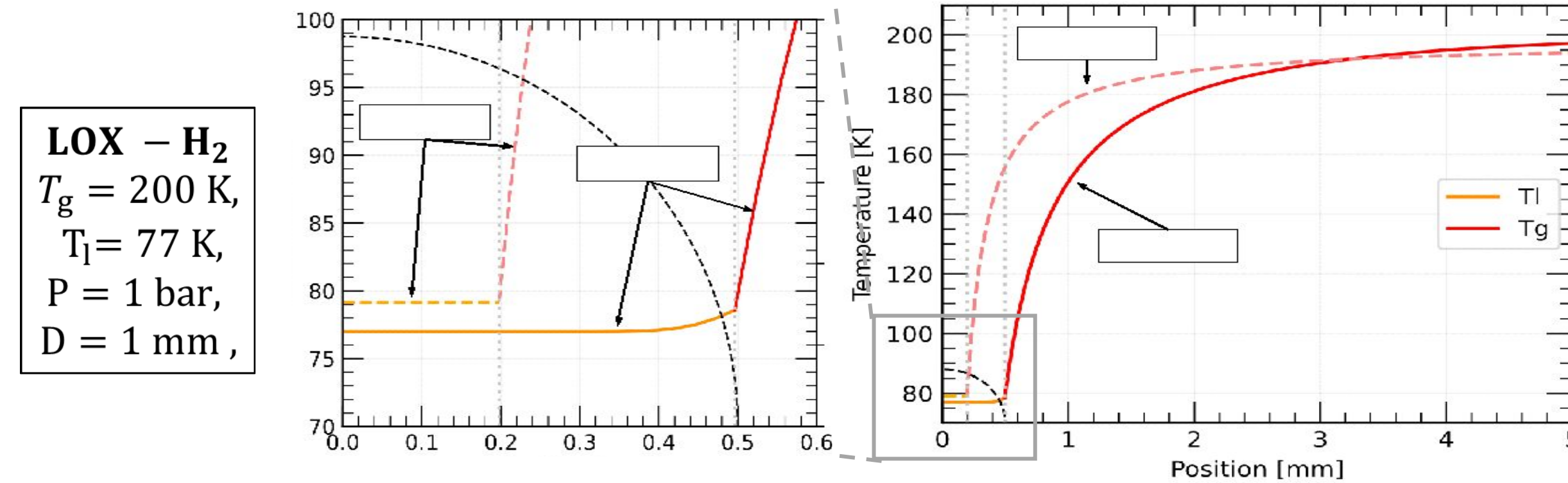


Fig. 5: Evolution of temperature with time in the liquid (left) and gas phase (right) [4]

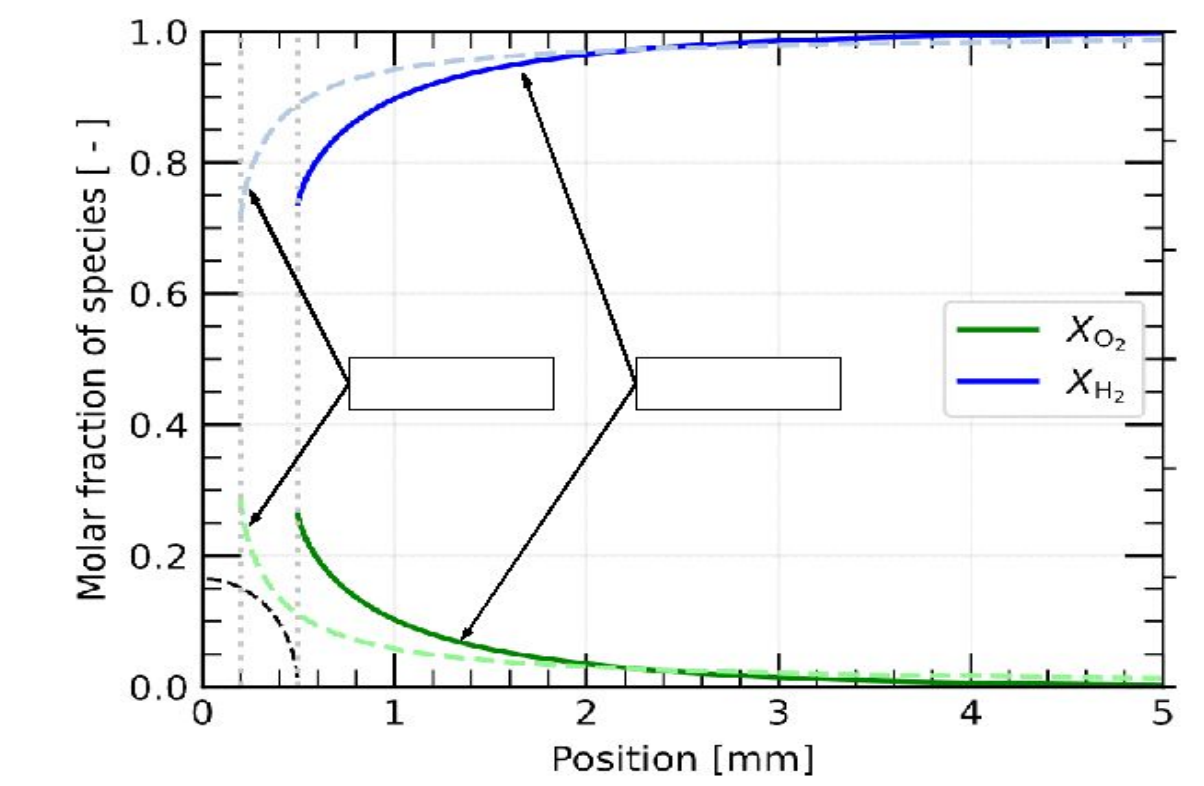


Fig. 6: Evolution of molar fractions with time [4]

Experimental setup & campaign

- An experimental setup was integrated into a drop tower capsule to study one LOX droplet combustion in H₂ under sub- and supercritical conditions
- Ice formation near the droplet surface observed during experiments

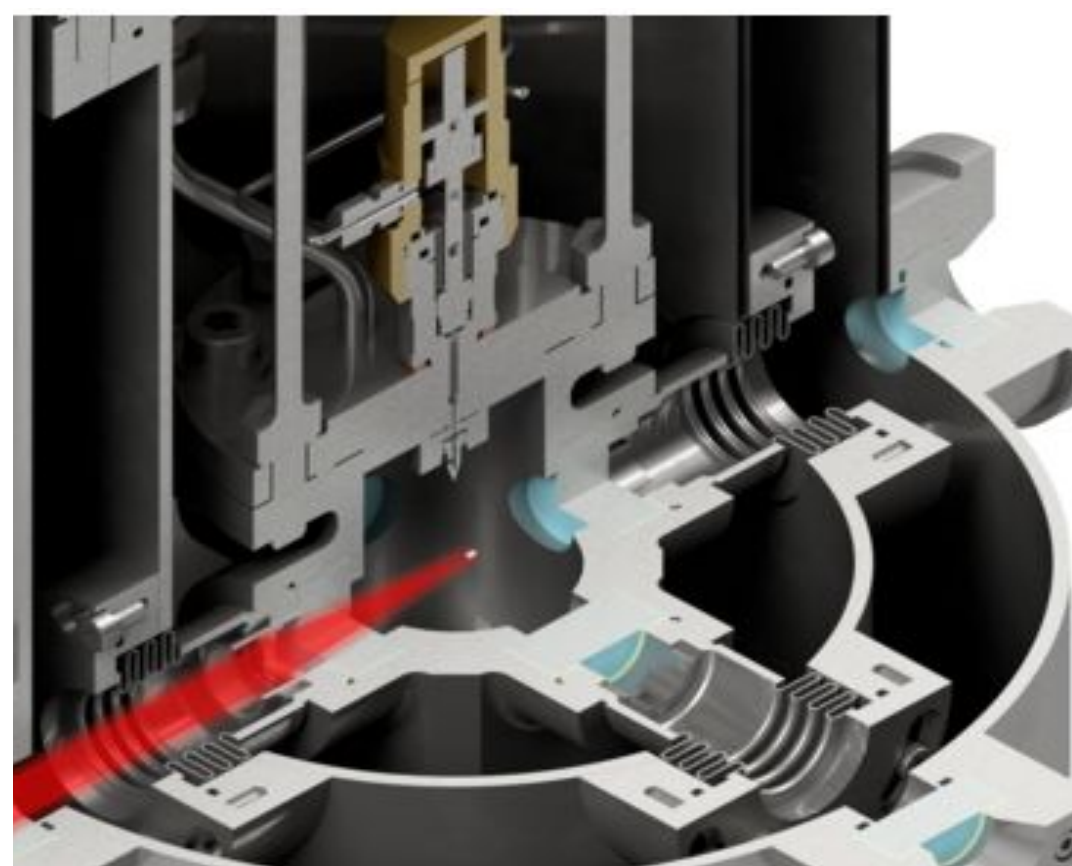


Fig. 3: Detail of the combustion chamber setup (CAD) [3]

OpenFOAM numerical simulation:

- Numerical modelling of the combustion of a single LOX droplet in gaseous H₂ is investigated to compliment experiments
- 1-D, spherically symmetric geometry in microgravity is assumed
- Methods: KIT's EBI-DNS [4] for the flame, coupled with our MATLAB liquid droplet phase simulator
- The computed flame stand-off distance is comparable to the experimental one
- The EBI-DNS model results in more accurate flame temperatures than earlier versions of OpenFOAM
- Limitation: Only gas phase solved, liquid oxygen droplet is not considered in the model

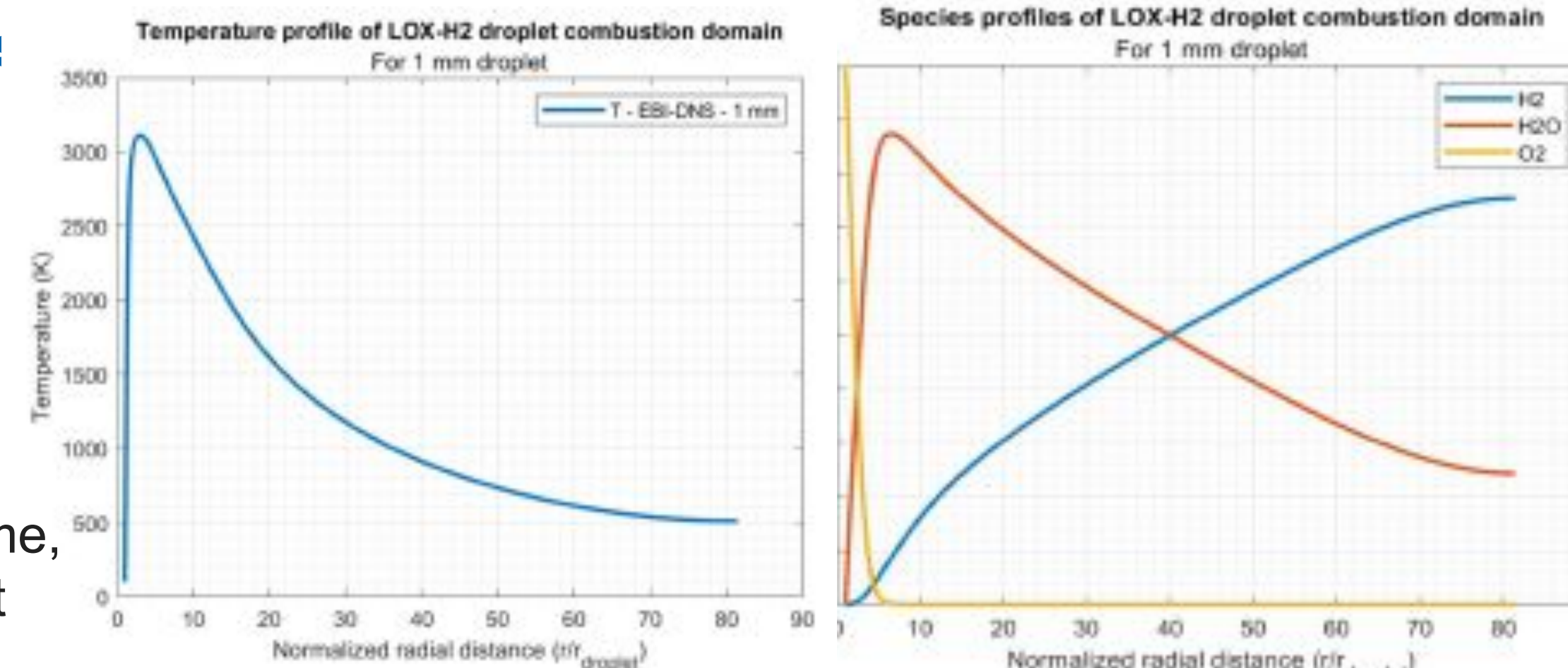


Fig. 4: Numerical flame simulation results EBI-DNS [1]

2017 – 2022

2023-2024

2025

Next steps

- Incorporate detailed combustion mechanisms
- Account for radiation and water ice formation at the droplet surface observed in experiments
- Validation of the model with existing drop tower experimental data

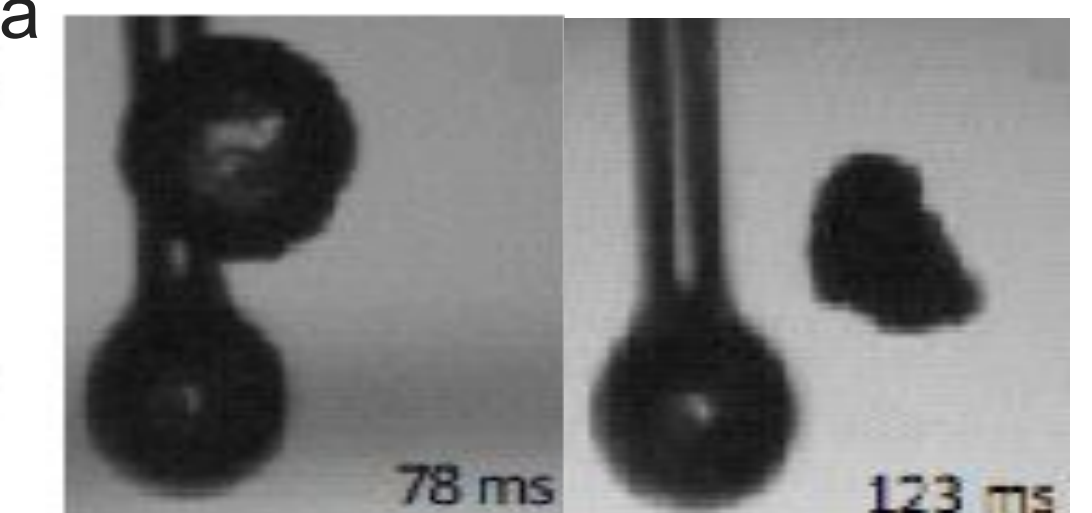


Fig. 7: Droplet surface ice formation [3]

References

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- Gupta M. "Numerical Investigation of the Combustion of Liquid Oxygen Droplets in an Environment of Hydrogen under Microgravity Conditions", University of Washington. Master's thesis, June 2021.
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