University of Stuttgart
Institute for Reactive Flows

Bachelor or Master Thesis

Assessment of differential and thermodiffusive transport effects in premixed hydrogen flames

Motivation

Premixed combustion is of great importance in modern energy systems, particularly for hydrogen as a clean energy carrier. Due to the high diffusivity of hydrogen, hydrogen-air flames are strongly affected by differential diffusion, especially under lean conditions, where thermodiffusive effects such as the Soret effect can further alter flame structure and propagation. While simplified transport models may be acceptable for fuels such as methane, they are often less suitable for hydrogen flames, which are much more sensitive to species-specific transport processes. A systematic comparison of transport modelling approaches is therefore required to assess their impact on Direct Numerical Simulation (DNS) and Multiple Mapping Condition (MMC) simulations of premixed hydrogen flames.

Project description and research goals

This project investigates the influence of transport modelling on premixed hydrogen flames by comparing two in-house DNS solvers with different treatments of species diffusion and thermodiffusive effects. Simulations will be performed across a range of equivalence ratios in order to identify under which conditions the differences in differential diffusion modelling and the inclusion of thermodiffusion lead to noticeable discrepancies in flame behaviour. The resulting discrepancies in flame structure and propagation will be analysed. In a second step, MMC simulations will be conducted using the same configurations. The impact of the underlying DNS transport modelling on MMC predictions will be assessed to evaluate its robustness for lean hydrogen combustion.

Tasks

- Conduct a literature review on differential diffusion and thermodiffusive effects in premixed hydrogen flames.
- Perform DNS simulations using two different transport modelling approaches.
- Compare results across different equivalence ratios and analyse discrepancies.
- **For MSc thesis:** Review the fundamentals of MMC and its application to premixed combustion.
- **For MSc thesis:** Run MMC simulations based on the DNS configurations and evaluate the results.
- Write a thesis and present the findings.

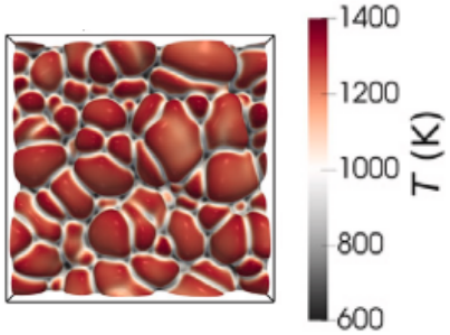

Figure 1: Iso-surface of Y_{H_2} for hydrogen–air at $\phi = 0.4$ including Sorret diffusion.

Prerequisites

- Sound background in fluid dynamics and combustion, some programming experience with Matlab, Python, or similar
- Beneficial: knowledge in C/C++, experience with computational fluid dynamics (CFD), OpenFOAM

Contact

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