International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

LES of thermodiffusively stable and unstable Bunsen flames

D. Cavalieri[1]*, C. Matteucci[1]*, D. Schintu[1], D. Cecere[2], G. Troiani[2], P. E. Lapenna[1] , F. Creta[1]
*Lead presenter: davide.cavalieri@uniroma1.it
[1] Department of Mechanical and Aerospace Engineering, Sapienza University of Rome, Italy
[2] Laboratory of Processes & Systems Engineering for Energy Decarbonisation, ENEA, Rome, Italy

Turbulent premixed hydrogen–air flames are strongly influenced by the differential diffusion, which promotes the onset of intrinsic flame instabilities (IFI) due to destabilizing thermodiffusive (TD) effects. The presence of IFI significantly alters flame–turbulence interactions, leading to complex and rich flame propagation dynamics [1]. In this work, large eddy simulations (LES) of Bunsen-type flames are performed under TD stable and TD unstable conditions, selected to match a recent experimental dataset [2] with varying hydrogen content and turbulence intensity. A thickened flame model (TFM) with detailed transport and chemistry is used and different efficiency functions and wrinkling factors are tested to correctly reproduce the global consumption speed of the experiments. Results reveal a modified synergistic interaction between TD-driven IFI and turbulence when using a TFM. Therefore, this confirms the importance of accounting for subgrid scale modeling of TD effects leading to IFI. In fact, such a modeling aspect should be evaluated on the capabilities of generating an increased flame consumption speed not solely attributable to flame surface growth, but also to higher local stretch-induced reactivity. Available DNS data under similar thermochemical conditions [3], although in a slot flame configuration, are used to compare the ensuing flame-turbulence interaction in the TFM simulations.

References

[1] P. E. Lapenna, G. Troiani, F. D'Alessio and F. Creta. Synergistic interplay of thermodiffusive instability and turbulence in premixed flames. *Proceedings of the Combustion Institute*. 2024;480:74-77.

[2] G. Troiani, P. E. Lapenna, F. D'Alessio, F. Creta. Scaling transition of turbulent flame speed for thermodiffusively unstable flames. *Physics of Fluids*. 2024

[3] D. Cecere, G. Troiani, D. Cavalieri, P.E.Lapenna and F. Creta. DNS of a thermodiffusively unstable turbulent H2/air premixed flame: propagation and modeling aspects. *European-Combustion-Meeting*. 2025