New Dynamics of Triple Flames in Mixing Layers at Large Lewis Numbers

Remi Daou[1], Shumeng Xie[2], Joel Daou[3]*, Zheng Chen[2]
*lead presenter: joel.daou@manchester.ac.uk
[1] Université Saint-Joseph de Beyrouth, FI-ESIB, Lebanon
[2] Peking University, China
[3] University of Manchester, UK

We revisit the problem of triple-flame propagation in mixing layers, examining both unstrained and strained configurations. The study is conducted numerically within the thermo-diffusive approximation, assuming constant density, constant transport properties, and an Arrhenius chemical reaction model. The propagation speed of the triple flame —whether positive or negative—and its domain of existence are determined in terms of two key dimensionless parameters: (i) a parameter ε, inversely proportional to the square root of the Damköhler number, and (ii) the fuel Lewis number, *Le*.

A rich and previously unexplored dynamic emerges for Lewis numbers exceeding a critical threshold, where the triple flame transitions to a tail-less structure. Notably, these tail-less flames can exist both within and beyond the domain of existence of their underlying diffusion flames. This novel behaviour is primarily attributed to the differing responses of the leading-edge temperature of the triple flame and the temperature of the diffusion flame to variations in ε (or equivalently, the Damköhler number).

Furthermore, the tail-less triple flames can manifest as generalised flame balls in non-uniform mixtures, exhibiting either stationary behaviour or drifting motion with both positive and negative propagation speeds. This dynamic is more readily found in unstrained mixing layers, where it occurs at more accessible Lewis numbers (e.g., $Le \approx 1.6$), in contrast to strained mixing layers, which require significantly higher *Le* values. These findings have important implications for the understanding of point-source ignition in mixing layers, which will be discussed.