FLASH TALK- HPC SPANISH COMBUSTION WORKSHOP

ONE- AND TWO-HEADED QUASI-PLANAR HYDROGEN PREMIXED FLAMES

Friday 2nd of July

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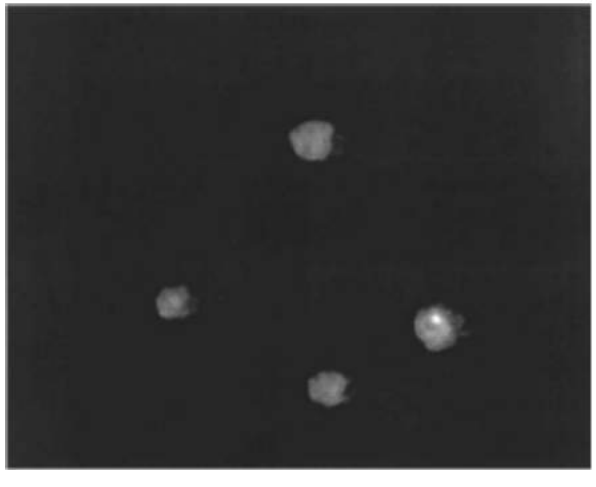
Proyecto S2-CARE. PID2019-108592RA-C43 / AEI / 10.13039/501100011033

Lean hydrogen-air premixed flames

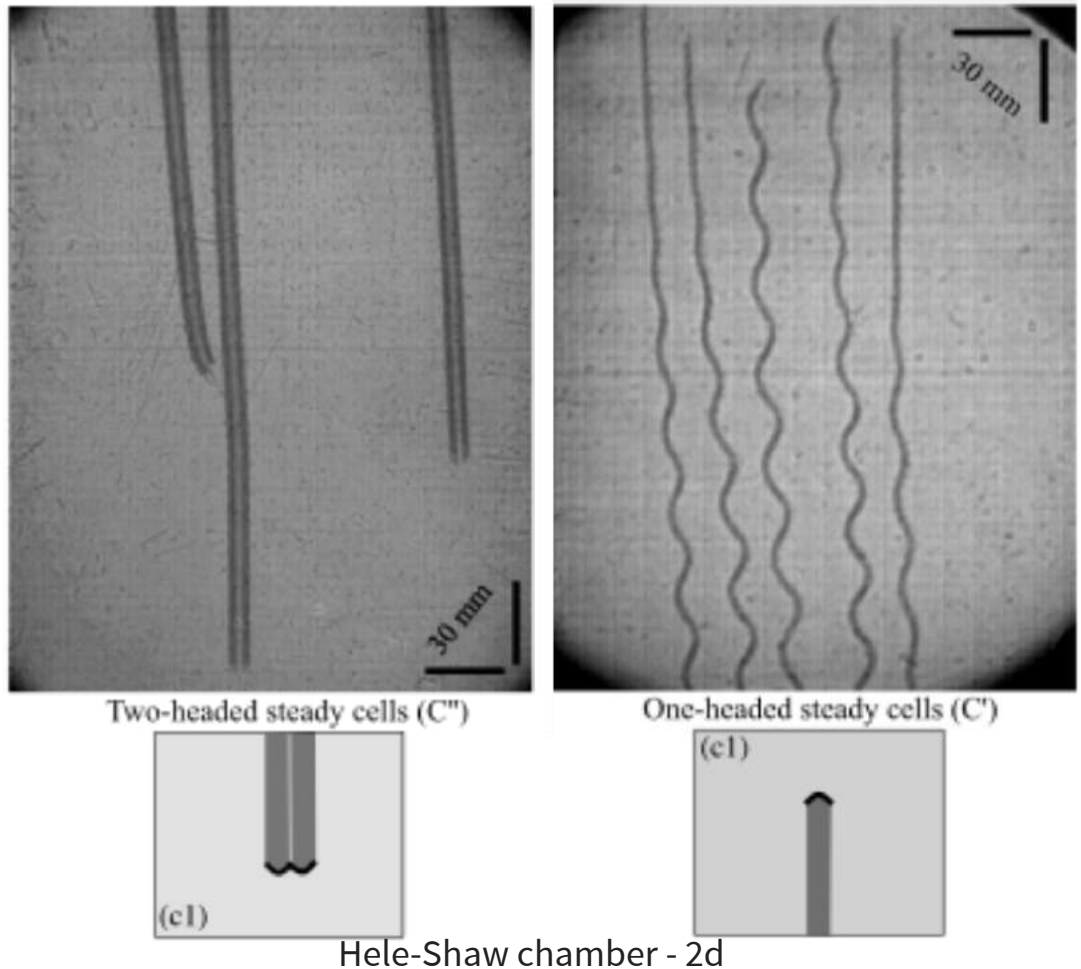
Ronney 3d experiments

P. D. Ronney. - Drop tower experiment, 1990



P. D. Ronney. - Columbia Shuttle, 1997

Veiga nearly-2d experiments



Hele-Shaw chamber - 2d

Veiga et al. - PRL, 2020

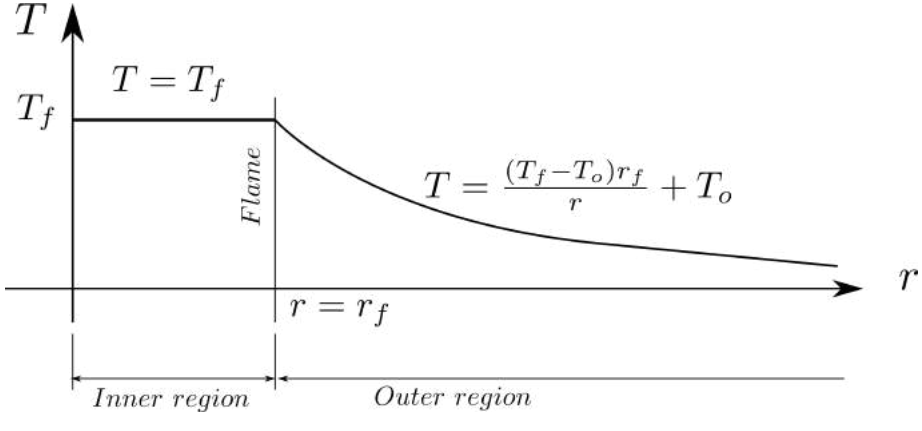
Theoretical model - Steady solution

Flame balls: Stationary spherical/circular premixed flames in which the only fluxes are diffusional. Lean premixed combustion with a low heat release (compared to the enthalpy of the reactants) where the thermal-diffusive method could be applied.

Thermal-diffusive model.
Sheet flame limit. Asymptotic limit of quick combustion process in which the reaction is confined to a infinitesimal region

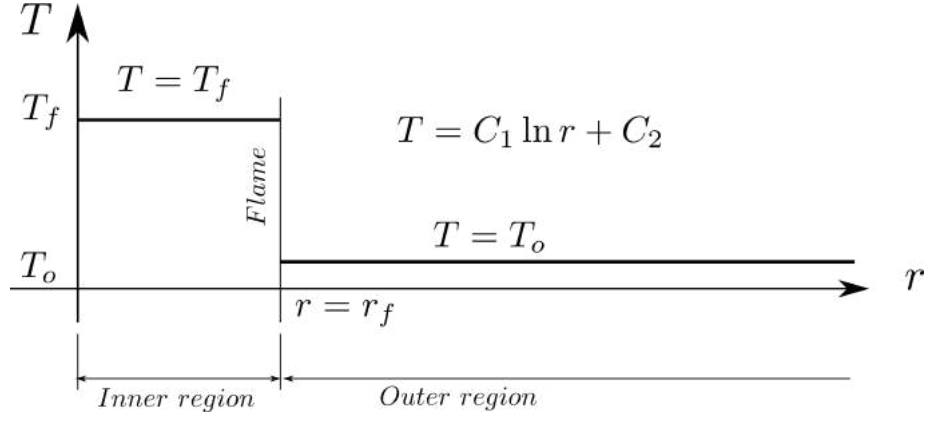
Spherical flame-ball

$$\frac{1}{r^2}\frac{d}{dr}\left(\lambda r^2 \frac{dT}{dr}\right) = 0$$
$$\frac{1}{r^2}\frac{d}{dr}\left(\rho D r^2 \frac{dY}{dr}\right) = 0$$



Two-dimensional flame-ball

$$\frac{1}{r}\frac{d}{dr}\left(\lambda r \frac{dT}{dr}\right) = 0$$
$$\frac{1}{r}\frac{d}{dr}\left(\rho D r \frac{dY}{dr}\right) = 0$$



Stationary solutions for the 2D case:

- Heat loses, f(T) $\rightarrow$ Steady solution for the energy equation only

$$\frac{1}{r}\frac{\partial}{\partial r}\left(\lambda r\frac{\partial T}{\partial r}\right) - f\left(T\right) = 0$$
$$\frac{1}{r}\frac{\partial}{\partial r}\left(\rho D r\frac{\partial T}{\partial r}\right) = 0$$

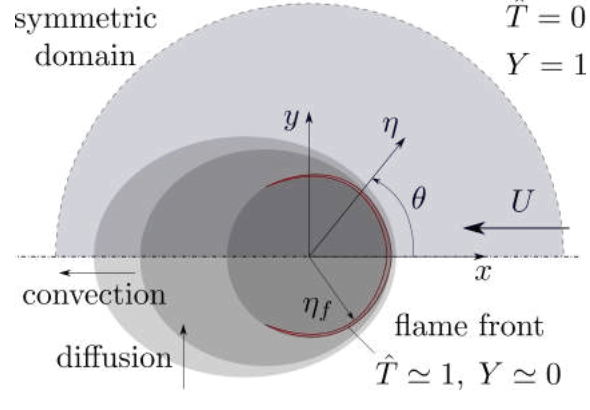
- Convective terms $\rightarrow$ Same terms for both equations

Could be the convection term the one in charge of making a stationary solution possible?

Thermo-diffusive model - convective terms

$$\eta = r/\delta_T, \quad \delta_T = D_T/S_L, \quad \mathcal{U} = U/S_L, \quad \hat{T} = (T - T_u)/(T_f - T_u)$$

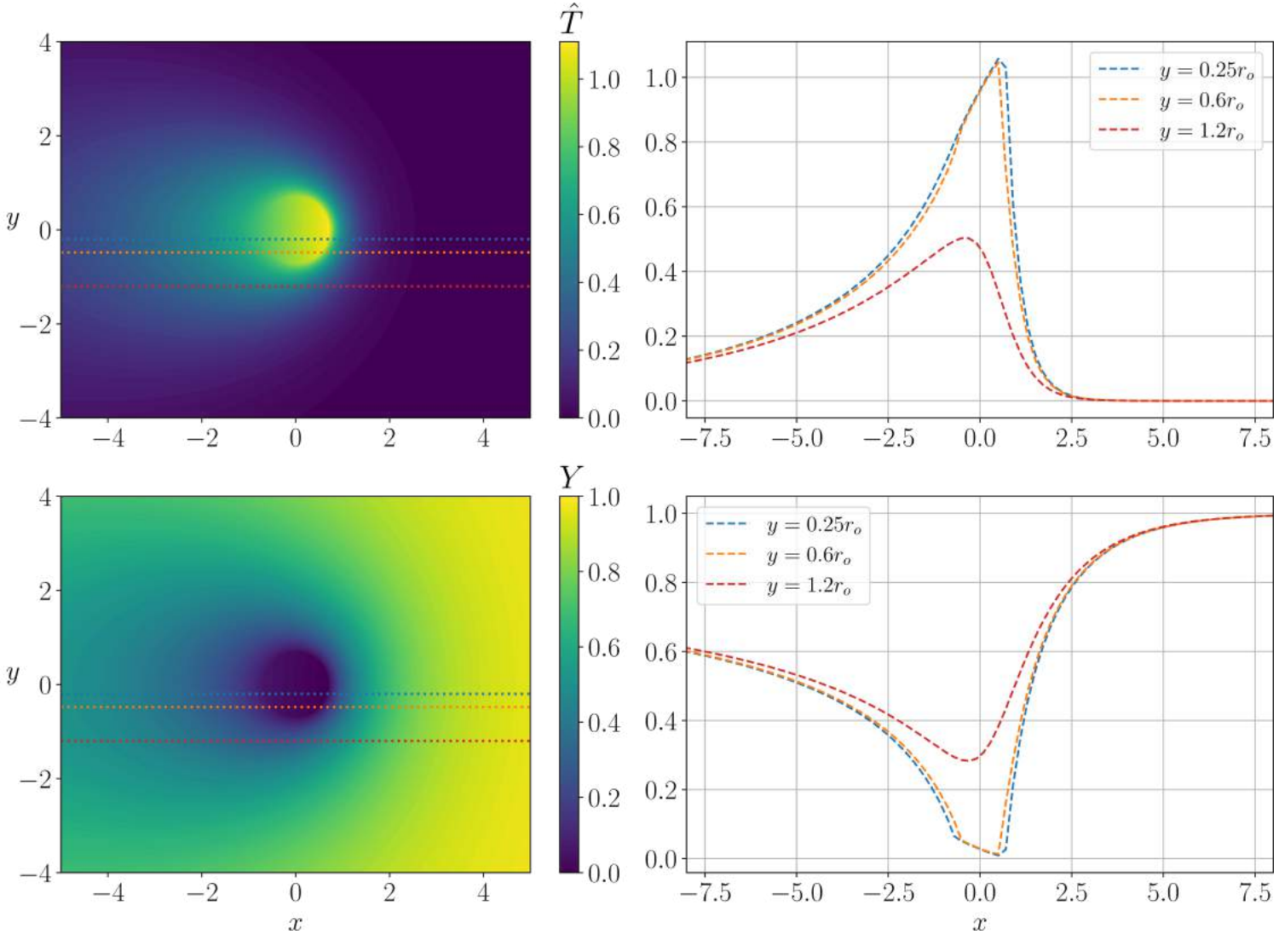
$$\mathcal{U}\left(-\cos\theta\frac{\partial \hat{T}}{\partial \eta} + \frac{\sin\theta}{\eta}\frac{\partial \hat{T}}{\partial \theta}\right) = \frac{1}{\eta}\frac{\partial}{\partial \eta}\left(\eta\frac{\partial \hat{T}}{\partial \eta}\right) + \frac{1}{\eta^2}\frac{\partial^2 \hat{T}}{\partial \theta^2} - b\hat{T}$$
$$\mathcal{U}\left(-\cos\theta\frac{\partial Y}{\partial \eta} + \frac{\sin\theta}{\eta}\frac{\partial Y}{\partial \theta}\right) = \frac{1}{Le}\left(\frac{1}{\eta}\frac{\partial}{\partial \eta}\left(\eta\frac{\partial Y}{\partial \eta}\right) + \frac{1}{\eta^2}\frac{\partial^2 Y}{\partial \theta^2}\right)$$

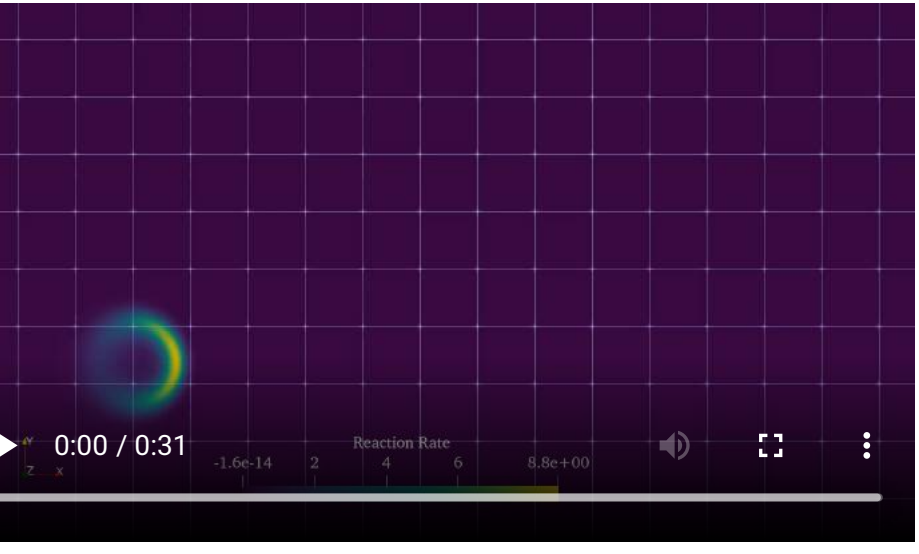


Numerical steady circular solution
Thermo-diffusive model

Temperature

Species Concentration



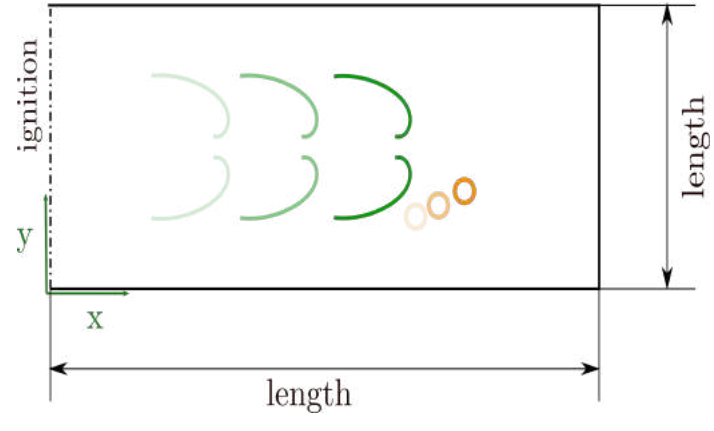


Numerical validation

Navier-Stokes equations. Free-FEM finite-element solver. Transversal integration of the equations for a quasi-2D description of a Hele-Shaw chamber.

Lean hydrogen-air confined premixed flames, using a one-step irreversible Arrhenius chemical model.

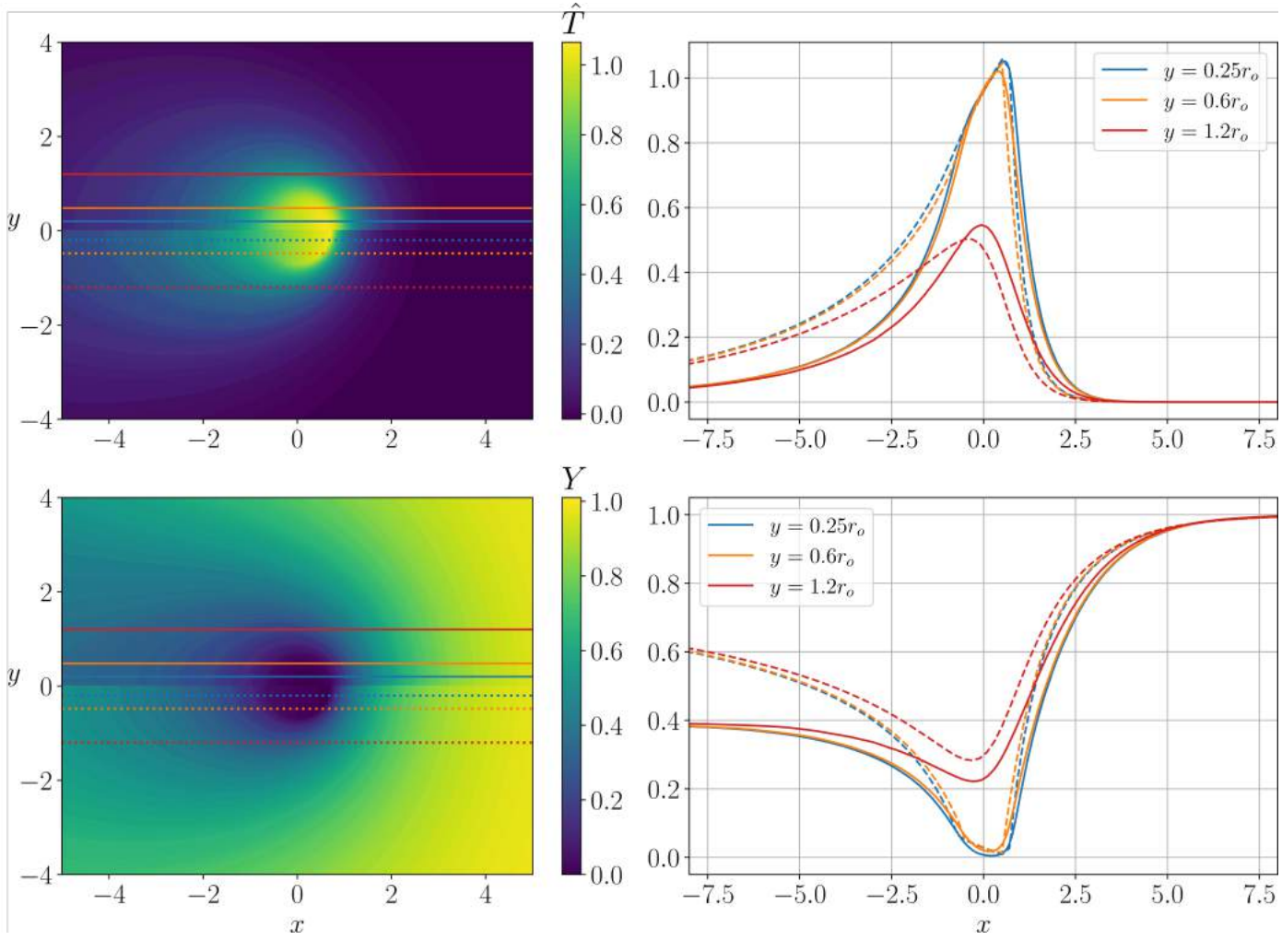
Mathematical formulation of: Martínez-Ruiz et al. - "The role of conductive heat losses on the formation of isolated flame cells in Hele-Shaw chambers". 2019



FreeFEM simulation - Thermo-diffusive model comparition

FreeFEM simulation

Thermo – diffusive model



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