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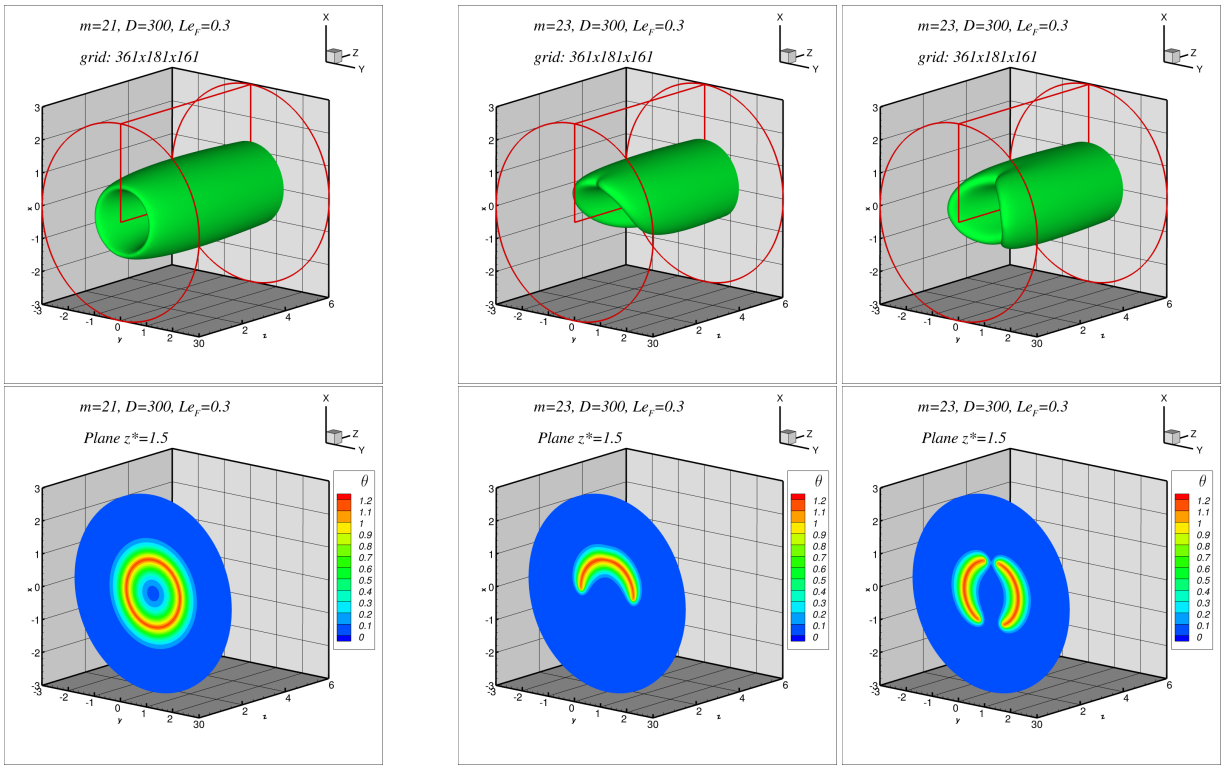
Non-axisymmetric edge flames in a circular channel

C. Jiménez [1]*, V. Kurdyumov[1]
*Lead presenter: carmen.jimenez@ciemat.es
[1] Energy Dpt. CIEMAT, Spain

A numerical study of the combustion process occurring after separate injection of fuel and oxidizer through an end-wall porous plug into a semi-infinite circular channel is presented. The fuel flow is injected into the center of the channel, surrounded by the oxidizer flow in an axisymmetric manner. It is assumed that the channel walls and the porous plug are kept at constant (cold) temperature. The study is based on a 3D thermodiffusive model using cylindrical coordinates with one-step Arrhenius-type combustion kinetics.
The structure of the combustion field consists of an edge flame located in the reactants' mixing layer and a diffusion flame following it. In a previous study, using 2D axisymmetric Navier–Stokes equations [1], it was shown that, for certain values of the parameters, the system can have multiple axisymmetric solutions, by effect of differential diffusion, when $\mathrm{Le}_F < 1$. Here, we show that, additionally, multiple non-axisymmetric solutions may exist.



Examples of axisymmetric and non-axisymmetric edge flame solutions. The two non-axisymmetric solutions (middle and right plots) correspond to the same set of parameters (and different initial conditions).

References

[1] Jiménez C and Kurdyumov VN. Edge-flames in circular channels: Multiplicity of steady-state axisymmetric solutions *Combustion and Flame*. 2024; 264: 113433.