4B10: THERMO-DIFFUSIVE INSTABILITIES IN AXISYMMETRIC, NON-PREMIXED JET FLAMES.

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**Comment by Godfrey Mungal, Stanford, USA**
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In your analysis m = 1 is often important. Practically this means that m = +/-1 are equally likely and can occur simultaneously. In [1] this was used to explain observations of jet instability modes in the far-field which result logically from the m = 0 mode in the near-field. How might the simultaneous occurrence of m= +/-1 modes affect the conclusions of your work?

Reference:

1. M. Yoda, L. Hesselink, M.G. Mungal, *J. Fluid Mech.*, Vol. 279 (1994) 313–350.

**Reply by Paul Papas:**
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First, it is important to emphasize that our linear stability analysis (LSA) does account for azimuthal modes m = +/-1, and our LSA has demonstrated that a m = 1 mode can be dominate for intermediate Lewis number flames near the extinction limit for fixed values of the jet Reynolds number ($Re_D$ = 200), ratio of the jet radius to initial momentum thickness ($R/\theta$ = 20), etc. It is also important to differentiate between the m = 0 mode that you are discussing for non-reacting jets, which is hydrodynamic in nature, and the m = 0 mode captured is our analysis for reacting jets, which is thermo-diffusive in nature and found near the flame extinction limit. To further explore the particular stability characteristics associated with m = +/-1, one would have to use results from the LSA, including mode shapes for m = 1, and to perform linearized Direct Numerical Simulations that would show the temporal evolution starting with various combinations of initial conditions with either m = 1 or m = -1. For our linear stability analysis, the m = 1 eigenmode shape and characteristics that we predict seems to closely correspond to the experimentally observed single cell flame structures for $CO_2$-diluted hydrogen-oxygen flames found near extinction ([8] in the paper). It is possible that, if the counter-rotating m = +1 and m = -1 modes have the same initial amplitude and growth characteristics, a particular solution can be obtained at long times which is planar-symmetric (not axisymmetry) around one plane and asymmetric in a plane perpendicular to the first. Such a case, for example, is investigated in an earlier study for non-reacting jets (Fig. 18 in [1]); this study indicates that parameters such as the jet Reynolds number and ratio of the jet radius to initial momentum thickness are important in determining whether the first helical mode or axisymmetric mode dominate in the near-field for non-reacting jets. Our conclusions and results in our paper, of course, are based on the particular jet parameters that we have chosen. The role of hydrodynamics on the thermo-diffusive type instabilities observed near extinction is an area that requires further research.

Reference:

[1] I. Danaila, J. Dusek, F. Anselmet, *Phys. Fluids* Vol 9 (11) (1997) 3323–3339.