LIMITING FLAME STRETCH RATES FOR FLAME INSTABILITIES AND FLAME QUENCHING

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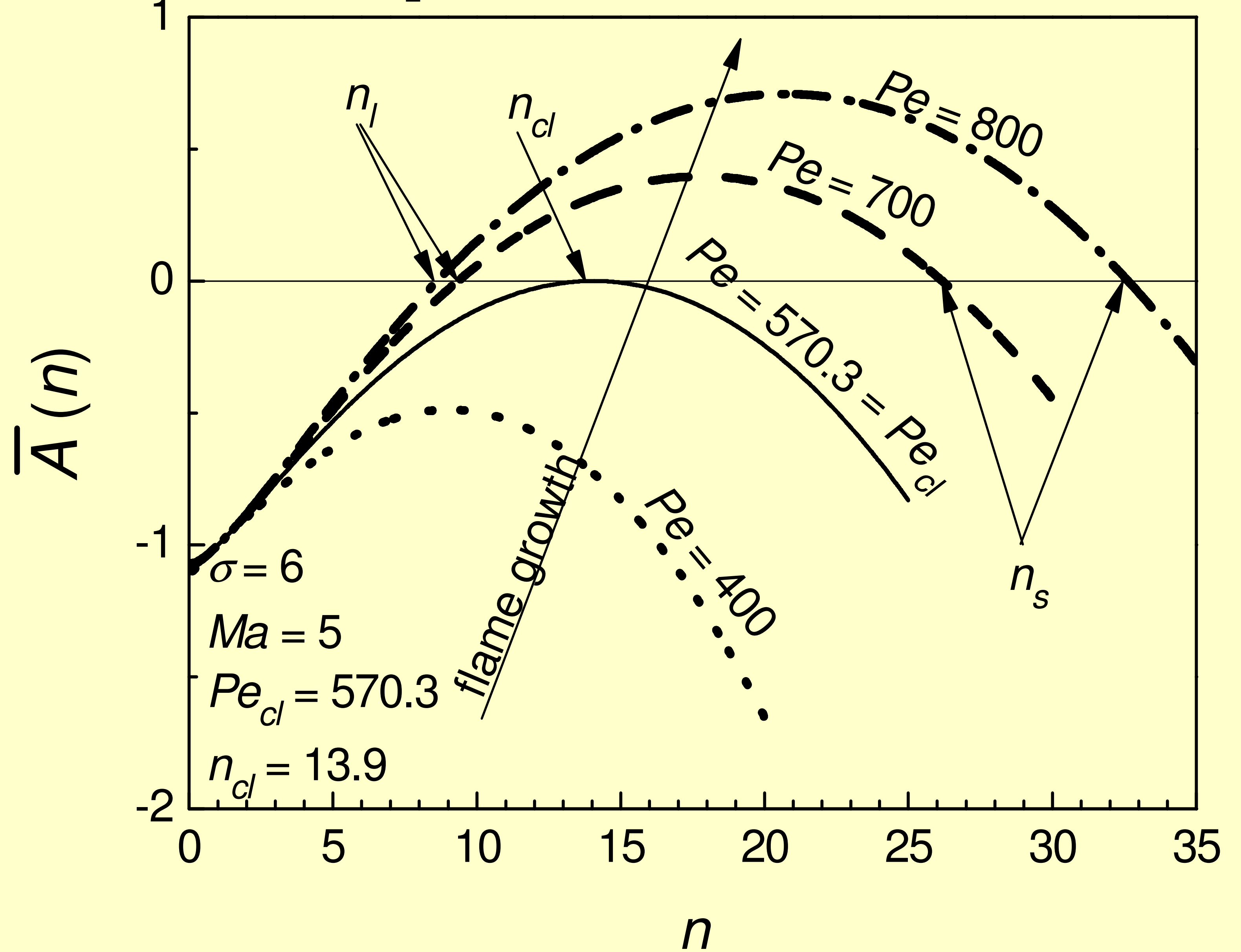
5th International Seminar on Fire and Explosion Hazards

$K_{0.8}$ K_{ql+}

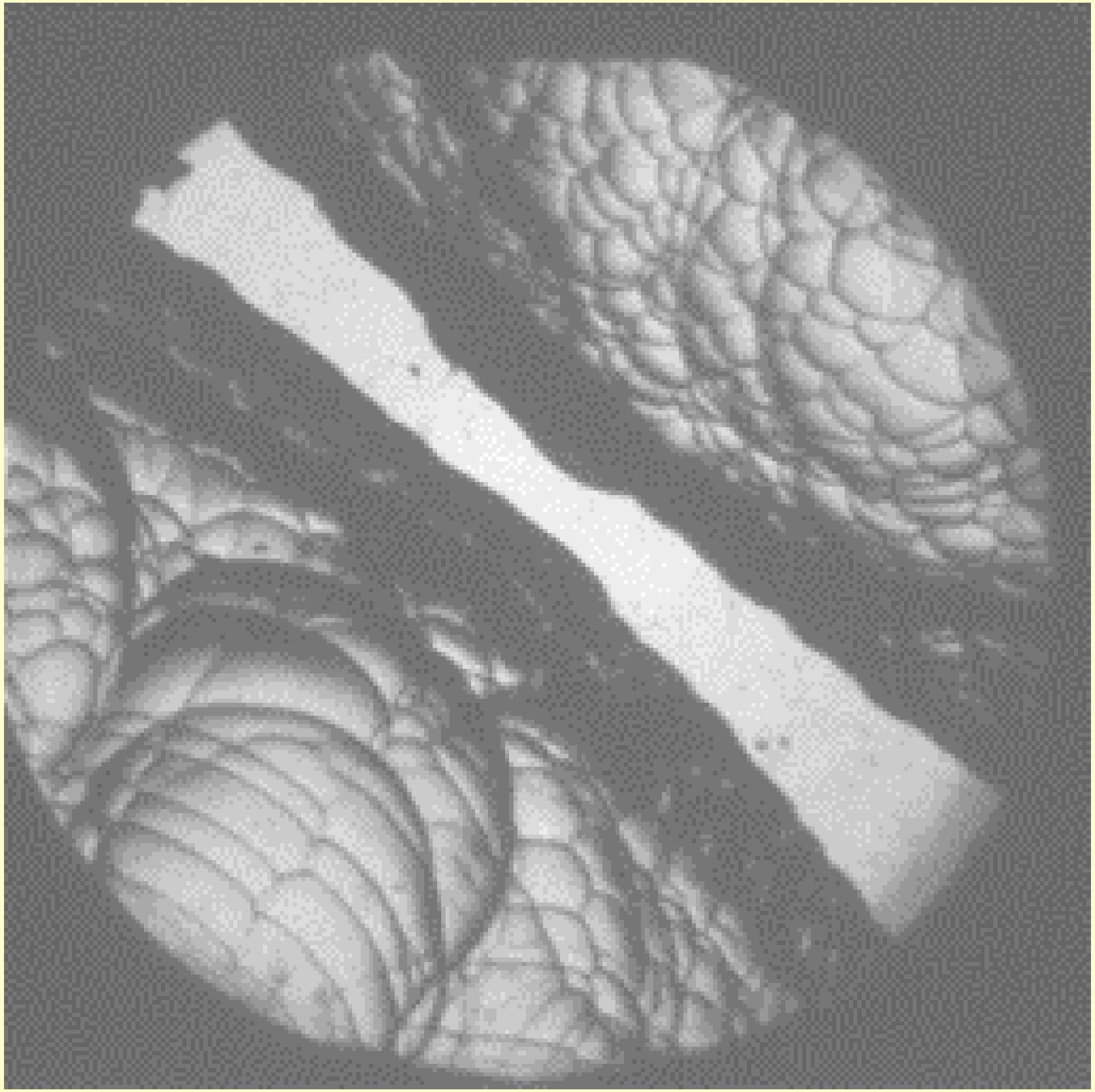
Instability, laminar and turbulent quenching

- Karlovitz stretch factor, K_{cl}, at which a stable laminar premixed flame becomes cellular.
- Karlovitz stretch factor for laminar flame quenching, K_{ql+}, by strain rate.
- Karlovitz stretch factor for a turbulent flame for the onset of flame quenching. For 80% probability of propagation, indicated by $K_{0.8}$.

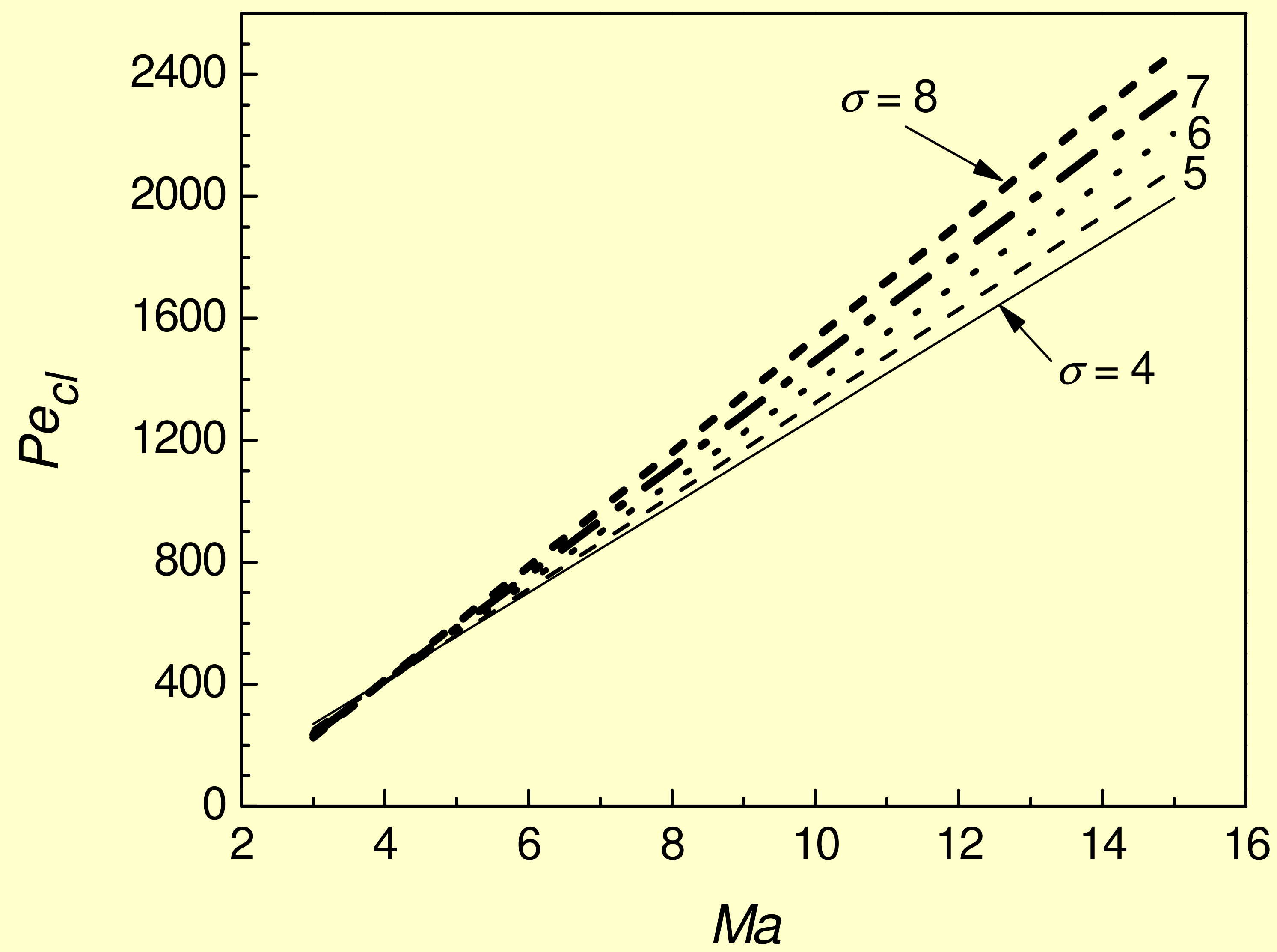
Spherical flame: growth rate of perturbation



Unstable twin explosion flames



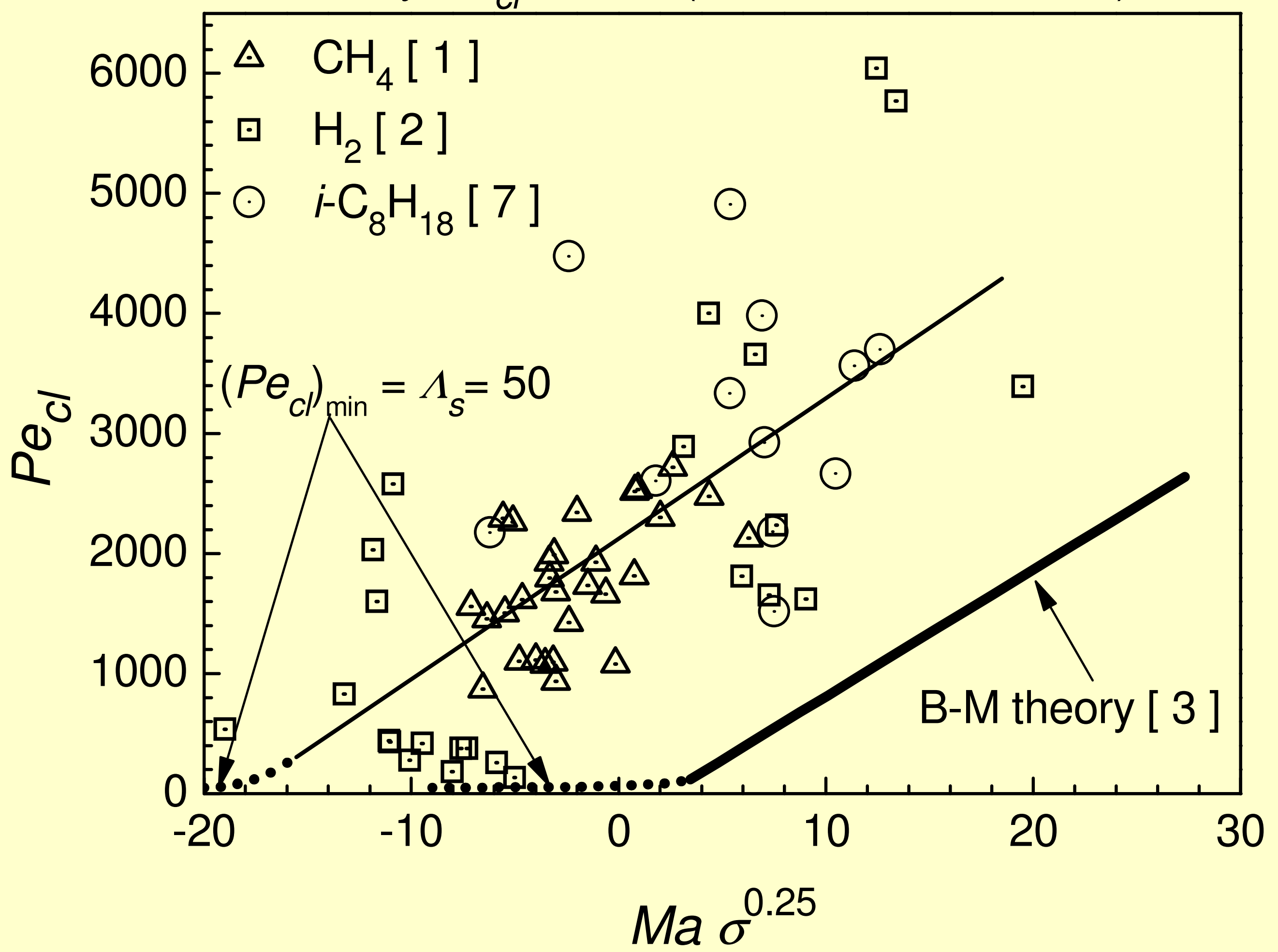
Dependence of critical Peclet number on Markstein number: theory



Dependence of critical Peclet number on Markstein number: experiment

Exp: $Pe_{cl} = 105 + (2019.8 + 117.0 Ma\sigma^{0.25})$

Theory: $Pe_{cl} = 105 + (-349.4 + 106.4 Ma\sigma^{0.25})$



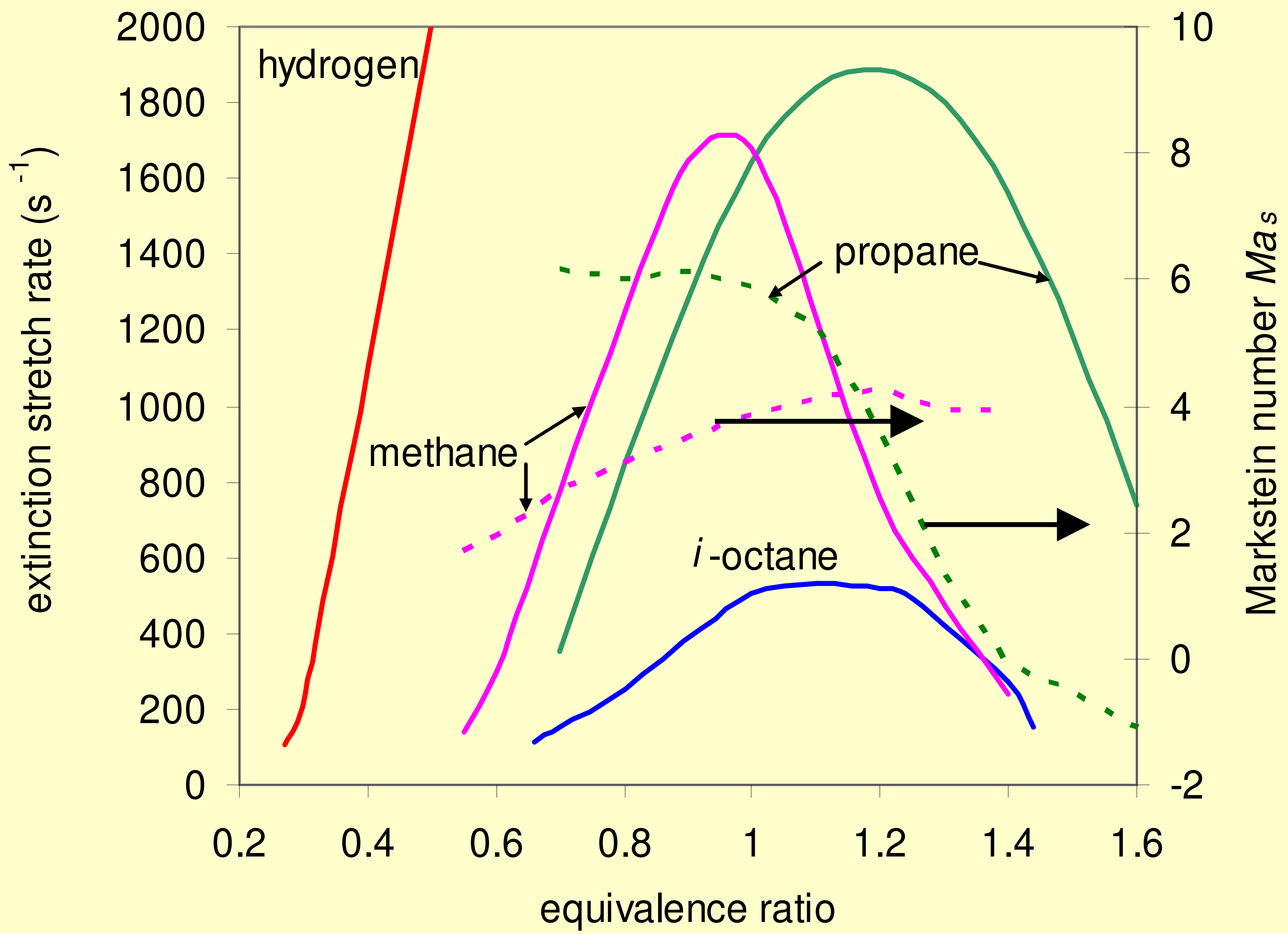
Derivation of K_{cl}

$$K_{cl} = \frac{2}{r_{cl}} u_{ncl}\, \sigma \left(\frac{\delta_\ell}{u_\ell} \right) = \frac{2}{Pe_{cl}} \frac{u_{ncl}}{u_\ell} \sigma$$

$$\frac{u_\ell - u_{ncl}}{u_\ell} = K_{cl} Ma$$

$$K_{cl} = \left[\left(Pe_{cl} / 2\sigma \right) + Ma_{sr} \right]^{-1}$$

Positive stretch rates for extinction of laminar flames



Derivation of K_{ql+}

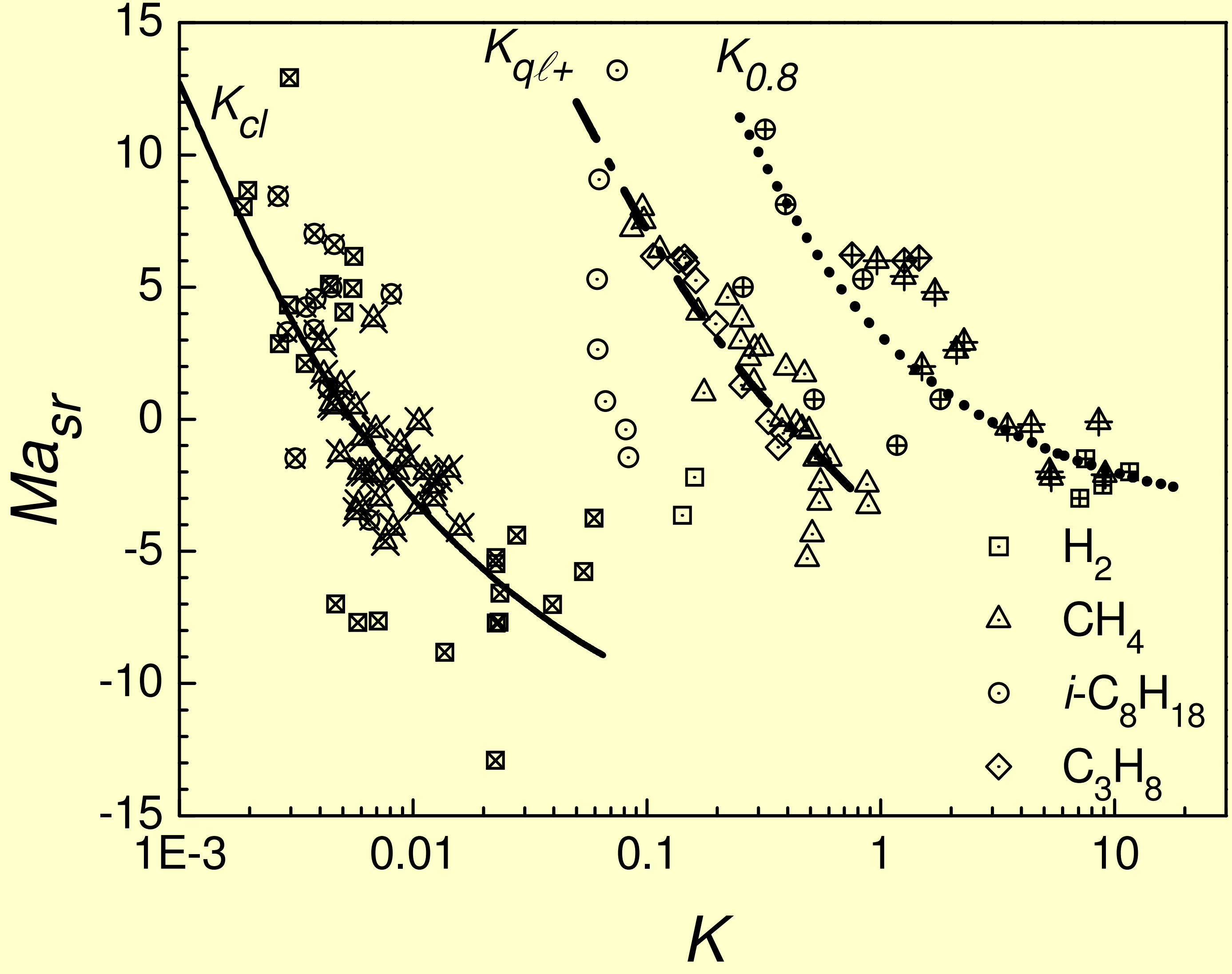
$$K_{ql+} = \alpha_{ql+}\left(\frac{\delta_\ell}{u_\ell}\right)$$

Derivation of $K_{0.8}$

$K_{0.8}$ expresses the turbulent Karlovitz stretch factor for an 80 % probability that the flame will continue to propagate. It is measured experimentally and a correlation of results is

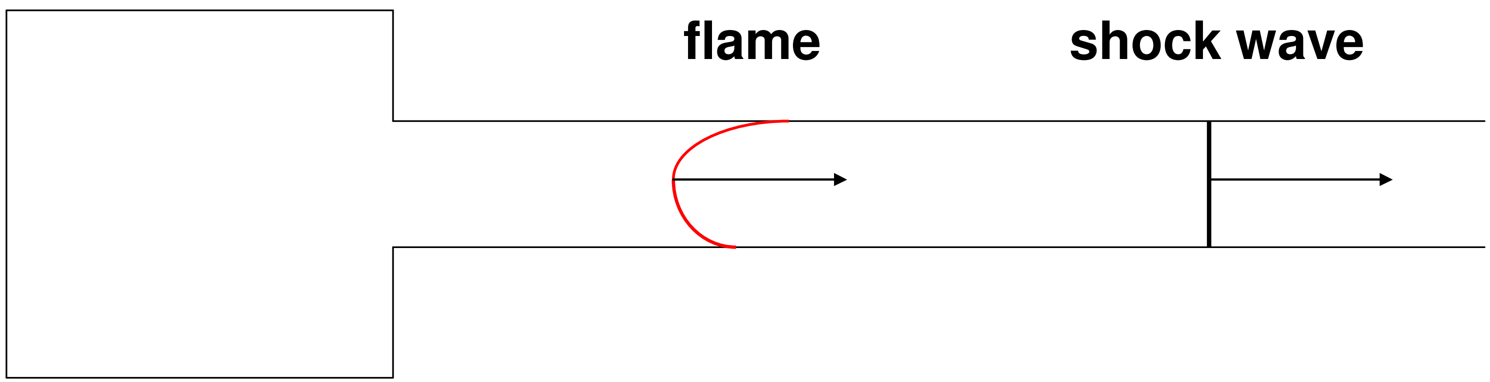
$$K_{0.8}\left(Ma_{sr}+4\right)^{1.8} = 34.4$$

K_{cl}, K_{ql+} and $K_{0.8}$ as a function of strain rate Markstein number



Flame propagation along ducts

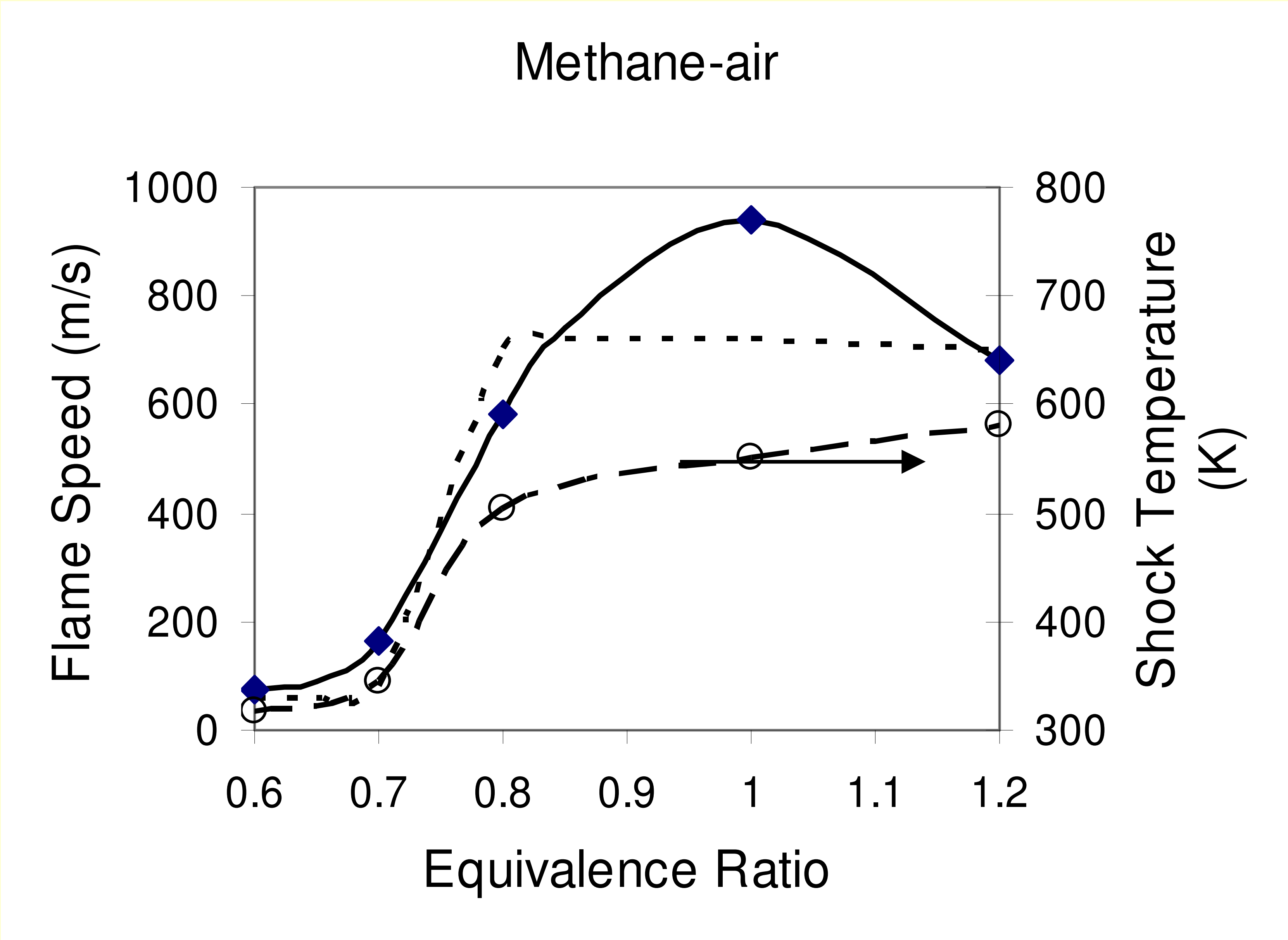
Deflagration/Detonation Transition



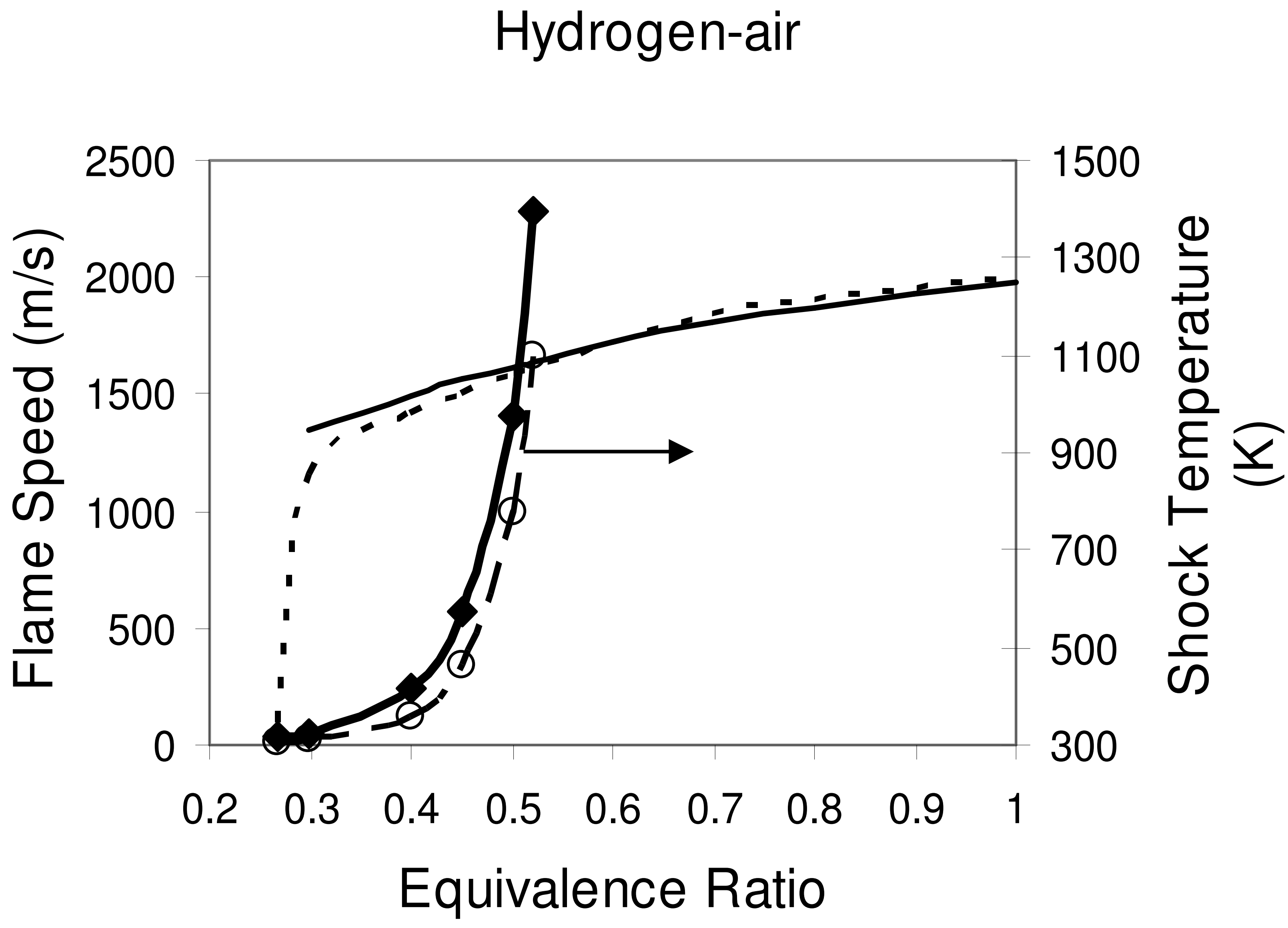
Runaway Flames

- Darrieus-Landau instability
- Runaway flame with increasing turbulence
- Limiting, maximum, turbulent burning velocity
- Creation of shock wave
- Possible autoignition

Methane –air Runaway



Hydrogen-air Runaway



Conclusions

The basic nature of flames can be characterised by Karlovitz stretch factors for:

*Onset of laminar flame instabilities

*Laminar flame quenching

*Turbulent flame quenching.

These are all relevant to transitions from deflagration to detonation.