HW III

Q1 (15 points). Under the atmospheric conditions, estimate the flame thickness (the characteristic scale of the preheat zone) for: (a) the methane-O2 flame; (b)the H2-O2 flame. Property parameters may be acquired via any available sources.

Q2 (30 points). The derivation of the burning velocity of laminar premixed flames is based on the following equations:

• mass conservation: $\dot{m} = \rho u = const.$

• species mass balance (for the simplified one-step reaction mechanism case):
$\dot{m}\frac{dY_i}{dx} = D\rho\frac{d^2Y_i}{dx^2} - \dot{\omega}_i,$
where $\dot{\omega}_i = \nu_i W_i \dot{\omega}$ $(i = F, O_2)$. Here ν_i is the stoichiometric coefficient and W_i is the molecular weight of i. The model for the reaction rate term $\dot{\omega}$ is $\dot{\omega} = B(\rho\frac{Y_f}{W_f})(\rho\frac{Y_{O2}}{W_{O2}})exp(-\frac{E}{RT})$.

• energy equation in the temperature form: $\dot{m}C_p\frac{dT}{dx} = \lambda\frac{d^2T}{dx^2} + Q\dot{\omega}_i$.

Review the derivation of the burning velocity. Discuss the dependence of S_L on ϕ (make all the necessary assumptions and simplifications if needed).

Q3 (20 points): For the non-adiabatic thermal explosion problem, use the asymptotic method (perturbation based on some small parameter), derive the temperature evolution equation.

Q4 (35 points): For the ignition/extinction problem of a well mixed flowing system,

(1) reproduce the temperature equation introduced in lecture;

(2) numerically calculate the dependence of $\widetilde{T_f}$ on Da for different $\tilde{Ta}$ (the nondimensional activation energy) and plot your results;

(3) discuss the physics of ignition and extinction.