Turbulent combustion

Course code: ATC3		ECTS Credits: 1.5	
Department	: ET	**Lectures**	: 15h00
Lecturers	: A. Mura	**Tutorials**	:
Year of study	: 2nd year	**Laboratory sessions**	:
Semester	: 3rd semester	**Project**	:
Assessment method(s)	: 1 written test	**Home works**	:
Language of instruction	: English	**Total hours**	: 15h00
Type of courses	: Compulsory		

Objective: providing the student with physical and phenomenological bases of turbulent combustion

Prerequisites: Basics of combustion and fluid mechanics

Content:

1. **Basics of laminar flames structures:** Multicomponent reactive Navier-Stokes equations at low Mach number, simplification at unity Lewis number, coupling terms, stirred reactor concept (« thickened flames »): finite rate chemistry effects, introduction of the Damköhler number, premixed flame structures: characteristic thickness and propagation velocity, influence of strain and curvature, introduction of the progress variable, non premixed flames : introduction of the mixture fraction variable, application to the counterflow diffusion flame, phase diagrams and permitted domain, influence of in-plane strain-rate
2. **Basics of turbulence and closure problem associated with the reactive scalar**

Turbulence: characteristic time scales and length scales, spectral dynamics, direct numerical simulation versus LES or RANS modelling frameworks, classsical closures: RANS k-eps and LES Smagorinsky, mean (or filtered) reaction rate: closure attempts, fast and slow chemistry limits, turbulent transport closures

3. **Premixed turbulent flames and combustion**

Effects of the fluctuating velocity field, phenomenology as revealed from Bradley's experiments, the turbulent burning velocity and its possible relevance, combustion regimes and diagrams (Borghi, Peters), the thin flame limit, modelling strategies: principles of modelling, similarities and differences between the standard approaches, limits of available closures and current trends for further developments

4. **Non premixed turbulent flames and combustion**

Combustion regimes and flame structures, interaction with turbulence, high Da flames (chemical equilibrium), finite-rate chemistry effects and local extinctions, associated closures: algebraic models and transport équations, PDF closures, principles, panorama et limitation of available closures, non premixed flame stabilization and triple flame structures, partially premixed combustion

Recommended reading:

M. Barrère, R. Prudhomme, *Equations fondamentales de l'aérothermochimie*, Masson Eds., 1973
J.D. Buckmaster, G.S.S. Ludford, *Theory of laminar flames*, Cambridge University Press, 1982
Ya.B. Zeldovich, G.I. Barenblatt, V.B. Librovich, G.M. Makhviladze, *The mathematical theory of combustion and explosions*, Consultant Bureau, Plenum Publishing Corp., 1985
N. Peters, *Turbulent combustion*, Cambridge University Press, 2000
S.B. Pope (2000), *Turbulent flows*, Cambridge University Press
A. Favre (1976), *La turbulence en mécanique des fluides*, A. Favre, L.S.G. Kovasznay, R. Dumas, J. Gaviglio, M. Coantic (Eds.), CNRS Editions, 1976
H. Tennekees, J. Lumley (1972), *A first course in turbulence*, The MIT Press, Cambridge (Massachussets), 1972
V.R. Kuznetsov, V. Sabelnikov, *Turbulence and combustion*, Hemisphere Publishing Corporation, 1990
R. Fox, *Computational models for turbulent reacting flows*, Cambridge University Press, 2002.
R. Borghi and M. Destriau, *La combustion et les flammes*, Technip, 1997
R. Borghi and M. Champion, *Modélisation et théorie des flammes,* Technip, 2000
R.S. Cant and E. Mastorakos, *An introduction to turbulent reacting flows*, Imperial College Press, 2008
K.K. Kuo, *Principles of combustion*, Wiley, 1986
K.K. Kuo, R. Acharya, *Fundamentals of turbulent and multiphase combustion*, Wiley, 2012
M. Lackner, F. Winter, A.K. Agarwal, *Handbook of combustion*, Vol. 1, Wiley, 2010
C.K. Law, *Combustion physics*, Cambridge University Press, 2010
F.A. Williams, *Combustion theory*, Benjamin Cummins (Menlo Park), 1985

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