# MS17 Towards Consensus on the Studies of Flame Acceleration (FA) and Deflagration-to-Detonation Transition (DDT)

Organizers: V'yacheslav Akkerman

West Virginia University, United States

Understanding of sporadic acceleration of a deflagration front, potentially followed by a deflagration-to-detonation transition (DDT) event has both practical relevance and fundamental interest. One the one hand, premixed flame acceleration (FA) and DDT stand behind countless disasters, including explosions in power plants and mining accidents. On the other hand, FA and DDT are aimed to be utilized, in an energetically cheapest manner, in the next-generation advanced technologies such as micro-combustors or pulse-detonation engines. From the fundamental viewpoint, FA and DDT are intriguing phenomena with applications ranging from terrestrial combustion and inertial confined fusion to Thermonuclear Supernovae. At present, there is no satisfactory agreement between various groups analyzing FA and DDT as well as between the approaches they imply. Within the proposed minisymposium we aim to consolidate the entire multi-discipline knowledgebase of combustion intensification followed by a detonation initiation, get rid of existing discrepancies, and develop the strategy for future works. The minisymposium will comprise twelve presentations devoted to various aspects of FA and DDT - starting with such terrestrial applications as microchannels and pipes, microfoam emulsion and boundary layers, and ending with the Type Ia Supernovae. In particular, the impacts of surface conditions, energy losses, shear flows, combustion instabilities, differential diffusion and chemical kinetics on various FA and DDT scenarios in unobstructed and obstructed configurations will be discussed. A special attention will be paid to the numerical issues oftentimes encountered in the deflagration, detonation, FA and DDT applications such as the adaptive mesh refinement.

Contact: Vyacheslav.Akkerman@mail.wvu.edu

## MS17 Towards Consensus on the Studies of Flame Acceleration (FA) and Deflagration-to-Detonation Transition (DDT) 1

**Chair: V'yacheslav Akkerman**

Wednesday, May 8; 13:30 - 15:30; Room: Amsterdam

### Role of Chemical Kinetics in Flame Acceleration in Narrow Channels

**Viatcheslav Bykov**[1], Andrey Koksharov[1], Mike Kuznetsov[1], Victor Zhukov[2]

[1] Karlsruhe Institute of Technology, Germany

[2] German Aerospace Center (DLR), Germany

Rapid progress of computational methods to study transient combustion regimes can shed the light on the problem of sudden flame acceleration leading to detonation. In this study, a pseudo-spectral computational method is employed to investigate the flame acceleration mechanism and the flame propagation in confined and partially confined media. The present work is motivated by recent experimental observations reported a so-called shock-less regime of deflagration to detonation transition in H2/O2 mixtures. In the talk, results of computations and experimental observations are compared and discussed. The main focus is made on the sensitivity of the flame acceleration to different kinetic models.

Contact: viatcheslav.bykov@kit.edu

### Propagation of Symmetric and Non-symmetric Flames in Channels: The Differential Diffusion and Compressibility Effects.

**Anne Dejoan**, Carmen Jiménez, Vadim Kurdyumov

CIEMAT, Spain

Symmetry loss of premixed flames propagating in narrow channels, planar and circular, is investigated. It is found that, depending on the flow rate, the Lewis number, the thermal expansion and the heat loss intensity, a bifurcation phenomenon can appear, leading to the existence of multiple solutions at the same set of parameters. In particular, the parametric influence on the critical bifurcation values is presented. Time-dependent simulations reveal that, as a general rule, symmetric flames are unstable with subsequent formation of non-symmetric flames. These results can be very important for practical applications, affecting, for example, the point of flashback.

Contact: anne.dejoan@ciemat.es, carmen.jimenez@ciemat.es, vadim.k@ciemat.es

## Influence of the Heat-Losses on Fast and Slow Flame Propagation in Long Narrow Channels From a Closed End

**Vadim Kurdyumov**[1], Moshe Matalon[2]

[1]CIEMAT, Spain
[2]University of Illinois at Urbana-Champaign, United States

Motivated by recent studies on the dynamics of isobaric and non-isobaric premixed flames in long narrow channels, attention is focused on the impact of the heat-losses when a combustible mixture is ignited at one end which is retained closed thereafter. An asymptotic method exploiting the different length scales allows to reduce the multi-dimensional problem to a one-dimensional one and the traveling-wave type of solutions is investigated asymptotically and numerically. It is demonstrated that the heat-losses control the transition between slow and fast flame propagation regimes leading in some cases to multiplicity of the flame propagation solutions.

Contact: vadim.k@ciemat.es

## Deflagration-to-Detonation Transition: Numerical Issues

**Leonid Kagan**[1], Andrey Koksharov[1], Peter Gordon[2], Gregory Sivashinsky[1]

[1]Tel Aviv University, Israel
[2]Kent State University, United States

Successful numerical simulations of deflagration-to-detonation transition began fifteen years ago. Since that time many theoretical problems of the transition have been solved. However, numerical studies per se suffer from a serious unsolved issue relating to resolution. It is generally agreed that a finer grid yields more accurate results. Yet, a finer grid demands a more powerful computational facility. The present study is concerned with the following practical points: (i) how to prove the convergence of the solution (ii) how to estimate the resolution required, (iii) why the degree of convergence differs from the degree of approximation.

Contact: kaganleo@post.tau.ac.il

## Universal Mechanism of the Unconfined Deflagration-to-Detonation Transition in Terrestrial Chemical Systems and Type Ia Supernovae

**Kareem Ahmed**[1], Alexei Poludnenko[2], Jessica Chambers[1], Vadim Gamezo[3], Brian Taylor[4]

[1]University of Central Florida, United States
[2]Texas A&M University, United States
[3]Naval Research Laboratory, United States
[4]Air Force Research Laboratory, United States

Unconfined deflagration-to-detonation transition (DDT) occurs in a variety of settings - from industrial explosions on Earth to stellar explosions in astrophysical systems, namely in type Ia supernovae (SNIa). The mechanism of detonation initiation in unconfined systems remains poorly understood both in chemical and thermonuclear reacting flows. Here, we present the general theory of the unconfined, turbulence-induced DDT. We expand upon our previous study, which suggested that detonation can be spontaneously formed by subsonic turbulent flames propagating with the speed faster than that of a Chapman- Jouguet deflagration. Here we derive critical turbulent conditions necessary to trigger the runaway process, which can lead to the DDT. Furthermore, we demonstrate the validity of this theory in three contexts: 1) direct numerical simulations (DNS) of fast premixed turbulent flames in chemically reacting systems (hydrogen-air and methane-air); 2) experimental studies of this DDT process in a Turbulent Shock Tube facility at the University of Central Florida; and 3) DNS of unconfined turbulent thermonuclear flames in a degenerate 12C stellar plasma representative of the conditions present in the white dwarf interior during a SNIa explosion.

Contact: apoludn@tamu.edu

## Flame acceleration and transition to detonation in hydrogen-based microfoams and foamed emulsions

**Alexey Kiverin**, Ivan Yakovenko, Alexey Korshunov, Boris Kichatov

Joint Institute for High Temperatures of RAS, Russia

A numerical model is proposed for the combustion of combined fuel - heptane-based foamed emulsion bubbled with the hydrogen-oxygen mixture. Foamed emulsion comprises gaseous bubbles dispersed in a large amount of liquid. Therefore, gas-dynamics of combustion proceeds at the background of processes related to the liquid films decay, droplets formation, their fragmentation and evaporation. Since the liquid phase contains fuel droplets the heterogeneous combustion also should be taken into account. On the basis of the proposed model, the process of flame acceleration and transition to detonation is considered in details. The basic mechanisms determining combustion and detonation evolution are disclosed.

Contact: alexeykiverin@gmail.com

# MS17 Towards Consensus on the Studies of Flame Acceleration (FA) and Deflagration-to-Detonation Transition (DDT) 2

**Chair: V'yacheslav Akkerman**

Wednesday, May 8; 16:00 - 18:20; Room: Amsterdam