The 2nd International Workshop on Near-Limit Flames

July 27-28, 2019, Peking University, Beijing, China

Topic summary and discussions

Topic 1. Near-Limit Flames and Cool Flames (Zheng Chen)

Topic 2. Dynamics of Turbulent Flames (Isaac Boxx)

Topic 3. Detonation and Explosion (Hoi Dick Ng)

Topic 4. New Combustion Concepts (Isaac Boxx)

Topic 1: Near-Limit Flames and Cool Flames

- Transitions and structure of the blue whirl
- Supercritical Combustion: kinetic model & flame dynamics
- Near-limit hydrogen flame propagation in a thin layer geometry
- Hydrogen flammability limit & deflagration-to-flame-ball-transition
- High pressure auto-ignition delay & ultrahigh temperature flame
- Low-temperature chemistry and cool flames

Topic 1: Near-Limit Flames and Cool Flames

- **Blue whirl: What is it? Why? How to control & use? Larger scale?**
- **Supercritical Combustion: accurate kinetic and transport model ?**
- **Near-limit H_2 flame in a thin layer: propagation & instability ?**
- **Deflagration-to-flame-ball-transition: H_2 % vol. limit? Exp.?**
- **High P & T: Kinetics ? Measurements ? Flame experiments ?**
- **Cool flame: Flame structure ? Accurate LTC ?**

Topic 2: Dynamics of Turbulent Flames

- Premixed and Mixed-mode combustion
- Modelling S_T with Lagrangian Statistics of Propagating Surfaces
- Inner structure of near-limit flames for arbitrary combinations of strain and curvature
- Blow-off Dynamics
  - Gas Turbine flames
  - Bluff-body stabilized flames at elevated pressure

Topic 2: Dynamics of Turbulent Flames

- **Premixed and Mixed-mode combustion**
  - **Auto-ignition is well computed when HTC prevails but much more difficult in the presence of LTC.**
  - **Flames with extreme turbulence/broadened pre-heat zones and broadened reaction zones are very difficult to compute**

- **Modelling S_T with Lagrangian Statistics of Propagating Surfaces**
  - **Restricted to planar flames in HIT**
  - **Pressure, gas expansion and differential diffusion**

Topic 2: Dynamics of Turbulent Flames

- **Inner structure of near-limit flames for arbitrary combinations of strain and curvature**
  - **Negative strain rate flame conditions not accessible by canonical flames such as counterflow, stagnation point…**

- **Blow-off Dynamics**
  - **Highly dynamic – Different timescales, which is most relevant?**
  - **Heat-transfer vs fluid mixing/local extinction**

Topic 3: Detonation and Explosion

Detonation and Explosion Session

Topic # 3

Summary and Challenges

From fundamental issue to practical applications

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Foundation issue in detonation theory (Higgins)

- Essence of CJ condition (sonic condition) - highly successful for ideal detonation
- The exact form of closure condition for detonations with losses (curvature, confinement, etc.), reversible chemistry, or transient multidimensional structure has yet to be rigorously defined.
- Eigenvalue solutions for non-ideal detonation (losses, yielding confinement, inhomogeneity, etc.)
    - verify using higher order numerical codes coupled with reversible reaction and other non-ideal effects
- Multi-dimensional unstable cellular structure --> simplfied 1-D “average” model and apply such fundamental closure concept
    - How to determine the sonic locus and define the ‘hydrodynamic thickness’ of a real cellular unstable detonation

The role of chemistry (Chaumeix)

- (1st workshop in 2017) State-of-the-art numerical techniques/algorithm sufficient to model DDT?
- Current reaction mechanism accurate to predict autoignition delay, which whether or not is sufficient to predict the shock-to-detonation transition
- Effects of various additives/dilutions/critical thermodynamic conditions
- Full chemistry for the transition (not just the high temperature one)
- Shock-to-detonation transition (a way to isolate/study the effect of chemistry?)
- Works toward improving modeling of the autoignition delay
- Dominant role (Chemistry (potential) vs. gasdynamics (How)) and to predict full DDT phenomenon

Detonation initiation (hotspot) (Dai)

- Engine knocks phenomena
- Gradient mechanism - Zel'dovich, SWACER, etc.
- A number of characteristic parameters were defined and analyzed
- Works to further assess different types of gradient, refine those parameters and unify all regime maps for different fuels
- Fuel chemistry: effect of low-T chemistry on the detonation development

Flame acceleration and DDT (Wen)

- Large scale simulations are becoming possible and common for accidental explosion safety analysis
- More and more numerical software are being developed.
- Use and model practical situations, i.e., Concentration gradients, effect of obstacles
- Validation/benchmark cases (realistic "large scale" scenario) required
  - Identify optimal combination of different numerical, combustion model/techniques "or" assess new algorithm for generic FA/DDT applications

Detonation-based engines (Kasahara)

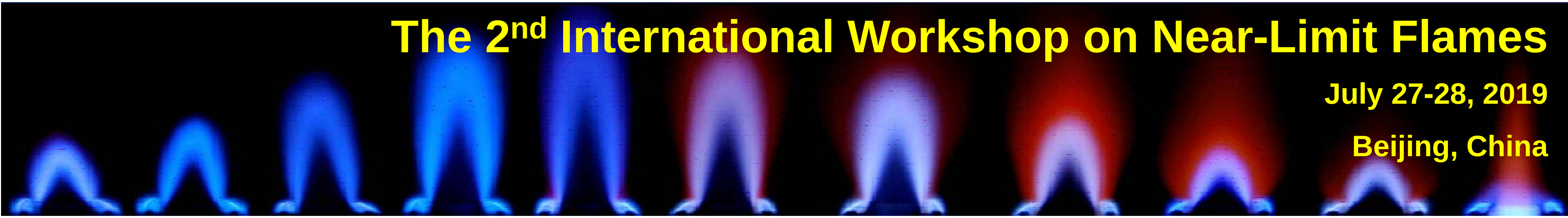
- Rotating/pulsed detonation engines
- Hot topic in the community (New design, flight demonstration, etc.)
- A number of outstanding issues which will be discussed this week in the ICDERS meeting (geometry, Fuel, injection, detonable mixture conditions, etc).
- Special session devoted to this topic

Topic 4: New Combustion Concepts

- Sequential Combustion
  - Auto-ignition
  - Plasma-activated autoignition
- MILD Combustion
  - Role of minor species
- Plasma Chemistry / Combustion Instability
  - Plasma assisted fuel Oxidation
  - Plasma stabilization of swirl flames
- Sub-to-supercritical Transition

Topic 4: New Combustion Concepts

- **Sequential Combustion:**
  - **Temperature/mixing effects**
  - **Role of plasma**
  - **Modelling autoignition /flame-propagation /thermoacoustics**
- **MILD Combustion / Fuel Flexibility**
  - **OH in coflow, formaldehyde production, O2 diffusion**
  - **Hydrogen addition**
  - **Challenge of operation at elevated pressure**
- **Plasma Chemistry / Combustion Instability**
- **Sub-to-supercritical Transition**



Thank you for attending this workshop !

Welcome to the 3rd workshop in 2021 !