Fourth International Conference on Numerical Combustion

December 2-4, 1991
TradeWinds Hotel © St. Petersburg Beach, Florida

Conference Themes
- Asymptotics and Numerical Experiments
- Complex Chemistry
- Detonations and Detonation Stability
- Drops and Sprays
- Fires
- Flame-Vortex Interaction
- Ignition
- Industrial Applications
- Laminar Flames
- Multiphase Combustion
- New Numerical Methods
- Supersonic Combustion
- Turbulence

Sponsored by SIAM with the cooperation of INRIA
Society for Industrial and Applied Mathematics
Institut National de Recherche en Informatique et en Automatique
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DEADLINE DATES
Hotel Reservations
November 2, 1991

Advance Conference Registration
November 25, 1991

ORGANIZING COMMITTEE
John Buckmaster, Co-Chair
Department of Aeronautical and Astronautical Engineering
University of Illinois, Urbana

Mitchell Smooke, Co-Chair
Department of Mechanical Engineering
Yale University

Paul Clavin
Laboratoire de Recherche en Combustion
Université de Provence, France

William A. Sirignano
School of Engineering
University of California, Irvine

Toshi Fujiiwara
Department of Aeronautical Engineering
Nagoya University, Japan

Jurgen Warnatz
Institut fur Technische Verbrennung
Universitat Stuttgart, Germany

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INRIA, Sophia-Antipolis, France

Charles Westbrook
Lawrence Livermore National Laboratory

Elaine Oran
U.S. Naval Research Laboratory

FUNDING AGENCIES
SIAM is conducting this conference with the partial support of the Air Force Office of Scientific Research and the Department of Energy.

GET-TOGETHERS
Welcoming Reception
Sunday, December 1
7:00 PM - 9:00 PM
Tarpon Key Room
Cash bar and assorted mini hors d'oeuvres.

Meet-and-Greet Hour
Monday, December 2
5:30 PM - 6:30 PM
Stop in after the sessions are over to meet new colleagues or greet old friends to talk about the day or just make plans for the evening. There will be cold beer, assorted sodas, and chips and pretzels with dip. Weather permitting, we will meet down by the beach. If weather is threatening, we will meet in the Fountain Court.
Following are subject classifications for the sessions. The codes in parentheses designate session type and number. The session types are: invited (IP), minisymposium (MS), and contributed (CP).

**Asymptotics and Numerical Experiments**
- Numerics and Asymptotics: A Symbiotic Approach to Detonation Physics (MS6, page 17)
- Numerics and Asymptotics: Some Basic Models in High Speed Propulsion (MS9, page 21)

**Complex Chemistry**
- Japanese Numerical Combustion (MS3, page 11)
- Methods of Approximation for Calculating Structures of Real Flames (IP2, page 8)
- Reduced Mechanisms for Combustion Calculations (MS2, page 9)

**Detonations and Detonation Stability**
- Comparison of Numerical Methods for Detonation Simulations (MS10, page 23)
- Detonations 1 and 2, (CP4 and CP7, pages 12 and 13), respectively
- Numerical Simulation of Several Reacting Gas Dynamic Phenomena (IP5, page 20)
- Numerics and Asymptotics: A Symbiotic Approach to Detonation Physics (MS6, page 17)

**Drops and Sprays**
- Droplets and Sprays (CP1, page 10)
- Droplet and Spray Analysis (MS8, page 20)

**Fires**
- Mathematical Modeling of Fires (MS4, page 11)

**Flame-Vortex Interaction**
- Simulations Specialized to Reveal Combustion Essentials (MS1, page 9)

**Ignition**
- Ignition (CP2, page 10)

**Industrial Applications**
- Japanese Numerical Combustion (MS3, page 11)
- Successes and Failures in Numerical Simulation of Gas-Turbine Combustion (IP6, page 20)
- Turbulence 3 (CP15, page 19)

**Laminar Flames**
- Laminar Diffusion Flames (CP9, page 15)
- Laminar Premixed Flames 1, 2, 3, 4, and 5 (CP11, CP14, CP16, CP18 and CP20, pages 18, 19, 22, 24, and 25), respectively
- Modeling Multidimensional Flames (IP3, page 14)
- Numerical Simulation of Laminar Reactive Flow (IP4, page 14)

**Multiphase Combustion**
- Multiphase Combustion 1, 2, and 3 (CP5, CP8, and CP19, pages 13, 15, and 24), respectively
New Numerical Methods
Grid-Free Simulation of Reacting Shear Flow at High Reynolds
Number (IP1, page 8)
Modeling and Algorithms 1 and 2, (CP3 and CP6, pages 12 and
13), respectively

Supersonic Combustion
Computational and Theoretical Approaches to Supersonic
Reacting Flows (MS5, page 14)
Numerical Simulation of Laminar Reactive Flow (IP4, page 14)
Numerics and Asymptotics: Some Basic Models in High Speed
Propulsion (MS9, page 21)
Simulation of Several Reacting Gas Dynamic Phenomena
(IP5, page 20)
Supersonic Combustion (CP13, page 19)

Turbulence
Simulations Specialized to Reveal Combustion Essentials
(MS1, page 9)
Successes and Failures in Numerical Simulation of
Gas-Turbine Combustion (IP6, page 20)
Turbulence 1, 2, 3, 4 and 5, (CP10, CP12, CP15, CP17 and
CP21, pages 16, 18, 19, 22, and 25), respectively
Turbulent Combustion (MS11, page 23)

1992 Conference Highlights

January 27-29, 1992
Third ACM-SIAM
Symposium on
Discrete Algorithms
Clarion Hotel, Orlando, FL
Sponsored by ACM-SIGACT and
SIAM Activity Group
on Discrete Mathematics
Organizer: Greg Frederickson,
Purdue University

May 11-13, 1992
Fourth SIAM Conference
on Optimization
Hyatt Regency Hotel, Chicago, IL
Sponsored by SIAM Activity Group
on Optimization
Co-organizers: Jorge Moré,
Argonne National Laboratory,
and Jorge Nocedal,
Northwestern University
Abstract Deadline: 10/11/91

June 8-11, 1992
Sixth SIAM Conference
on Discrete Mathematics
University of British Columbia,
Vancouver, Canada
Sponsored by SIAM Activity Group
on Discrete Mathematics
Organizer: Pavol Hell,
Simon Fraser University, Canada
Abstract Deadline: 11/15/91

July 19-24, 1992
SIAM 40th Anniversary
Meeting ♥ ♥ ♥
Century Plaza Hotel,
Los Angeles, CA
Organizer: James M. Hyman,
Los Alamos National Laboratory
Abstract Deadline: 1/6/92

September 17-19, 1992
SIAM Conference on Control
and its Applications
Radisson Hotel Metrodome
Minneapolis, MN
Sponsored by SIAM Activity Group
on Control and Systems Theory
Organizer: Kevin A. Gerlee,
University of Oklahoma, Norman
Abstract Deadline: 2/14/92

October 15-19, 1992
SIAM Conference on
Applications of Dynamical
Systems
Snowbird Ski and Summer Resort
Hotel, Salt Lake City, UT
Sponsored by SIAM Activity Group
on Dynamical Systems
Co-organizers: Peter W. Bates,
Brigham Young University,
and Christopher K. R.T. Jones,
Brown University
Abstract Deadline: 3/13/92
PROGRAM-AT-A-GLANCE

Monday, December 2

7:30  Registration opens  
      Fountain Courtyard

8:15  Welcoming Remarks  
      John Buckmaster  
      Long Key Ballroom

8:30  IP1 Grid-free Simulation of Reacting Shear Flow at High  
      Reynolds Number  
      Ahmed F. Ghoniem  
      Long Key Ballroom

9:15  IP2 Methods of Approximation for Calculating Structures  
      of Real Flames  
      Forman A. Williams  
      Long Key Ballroom

10:00 Coffee  
      Sabal Room

10:30 Concurrent Sessions (Minisymposia and Contributed)  
      MS1 Simulations Specialized to Reveal Combustion  
      Essentials  
      Organizer: William T. Ashurst  
      Jasmine Room

      MS2 Reduced Mechanisms for Combustion Calculations  
      Organizer: Norbert Peters  
      Long Key Ballroom

      CP1 Droplets and Sprays  
      Palm Room

      CP2 Ignition  
      Banyan Room

12:30 Lunch

2:00  MS3 Japanese Numerical Combustion  
      Organizer: Tadao Takeno  
      Long Key Ballroom

      MS4 Mathematical Modeling of Fires  
      Organizer: Ronald G. Rehm  
      Jasmine Room

      CP3 Modeling and Algorithms 1  
      Palm Room

      CP4 Detonations 1  
      Banyan Room

4:00  Coffee  
      Sabal Room

4:30  Concurrent Sessions (Contributed)  
      CP5 Multiphase Combustion 1  
      Long Key Ballroom

      CP6 Modeling and Algorithms 2  
      Jasmine Room

      CP7 Detonations 2  
      Palm Room

CP = Contributed Presentation; IP = Invited Presentation; MS = Minisymposium
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CP = Contributed Presentation; IP = Invited Presentation; MS = Minisymposium
Contributed presentations in a session are spaced twenty minutes apart, which allows fifteen minutes for each presentation and five minutes for discussion. Minisymposium talks are spaced thirty minutes apart, which allows for twenty-five minutes for each presentation and five minutes for discussion.
PROGRAM AT A GLANCE

Wednesday, December 4

8:00  Registration opens
      Fountain Courtyard

8:15  Closing Remarks by Mitchell D. Smooke
      Long Key Ballroom

8:30  IP5 Numerical Simulation of Several Reacting Gas
      Dynamic Phenomena
      Toshi Fujiwara
      Long Key Ballroom

9:15  IP6 Successes and Failures in Numerical Simulation of Gas-
      Turbine Combustion
      Sanjay M. Correa
      Long Key Ballroom

10:00 Coffee
     Sabal Room

10:30 Concurrent Sessions (Minisymposia and Contributed)
      MS8 Droplet and Spray Analysis
      Organizer: William A. Sirignano
      Palm Room

      MS9 Numerics and Asymptotics: Some Basic Models in
      High Speed Propulsion
      Organizer: Thomas L. Jackson
      Banyan Room

      CP16 Laminar Premixed Flames 3
      Jasmine Room

      CP17 Turbulence 4
      Long Key Ballroom

12:30 Lunch

2:00  Concurrent Sessions (Minisymposia and Contributed)
      MS10 Comparison of Numerical Methods for Detonation
      Simulations
      Organizer: D. Scott Stewart
      Palm Room

      MS11 Turbulent Combustion
      Organizer: Stephen Pope
      Long Key Ballroom

      CP18 Laminar Premixed Flames 4
      Jasmine Room

4:00  Coffee
     Sabal Room

4:30  Concurrent Sessions (Minisymposia and Contributed)
      MS10 Comparison of Numerical Methods for Detonation
      Simulations (Continuation from 2:00 PM)
      Palm Room

      CP19 Multiphase Combustion 3
      Banyan Room

      CP20 Laminar Premixed Flames 5
      Jasmine Room

      CP21 Turbulence 5
      Long Key Ballroom

5:30 Conference Adjourns
CP = Contributed Presentation; IP = Invited Presentation; MS = Minisymposium
CONFERENCE PROGRAM

Monday Morning, December 2

7:30/Fountain Courtyard
Registration Opens

8:15/Long Key Ballroom
Welcoming Remarks
John Buckmaster, University of Illinois, Urbana

8:30/Long Key Ballroom
IP1/Chair: Jay Boris, U.S. Naval Research Laboratory
Grid-free Simulation of Reacting Shear Flow at High
Reynolds Number
In the numerical simulation of high-Reynolds number, reacting shear
flows, the streamlines suffer severe distortion resulting from the growth of
successive instability modes which cause initially parallel streamlines to
become curved in the plane and normal to the plane of the flow. Moreover,
mixing in these flows is dominated by convective entrainment. Hence the
propagation of reaction fronts closely follows the streamlines. In this
context, Lagrangian, grid-free methods offer desirable properties.
This presentation focuses on the construction and application of the
transport element method, a natural extension of the vortex method in
which species conservation equations are solved by transporting the corre-
sponding scalar gradients.

Ahmed F. Ghenieh
Department of Mechanical Engineering
Massachusetts Institute of Technology

9:15/Long Key Ballroom
IP2/Chair: Jay Boris, U.S. Naval Research Laboratory
Methods of Approximation for Calculating Structures of
Real Flames
Real flames are described by the equations of chemically reacting fluid flow
with typically 20 to 2000 elementary reaction steps. Three-dimensional
time-dependent numerical computation of flames with so many steps is
beyond the capability of computers in the forseeable future. Therefore,
simplifications in the chemical kinetics and in the fluid mechanics are
needed if progress is to be made. Asymptotic methods afford avenues for
identifying reduced chemical-kinetic mechanisms that involve fewer steps
and for locating flow regions that maintain simplified balances. The
speaker will discuss some of these simplifications for both premixed flames
and diffusion flames.

Forman A. Williams
Department of Applied Mechanics and Engineering Sciences
University of California, San Diego

10:00-10:30/Sabal Room
Coffee
Concurrent Sessions (Minisymposia and Contributed)

MS1/Jasmine Room

Simulations Specialized to Reveal Combustion Essentials
Numerical simulations that treat one aspect of combustion in great detail, but treat other aspects more crudely, have been developed in order to highlight various aspects of combustion. Thus, full computer power is devoted to a single feature in each model and does that feature well, rather than poorly representing all features. The linear eddy model involves a one-dimensional representation of the thin diffusive layers found in turbulent mixing. Vortex rings are used to simulate the unsteady entrance flow in a pulse combustor and the impact of strain-rate quenching on premixed flame propagation is revealed in the rate of heat release. Direct simulations of constant density Navier-Stokes turbulence have been used to determine premixed flame geometry and the magnitude of differential diffusion.

In this minisymposium, the speakers will present different, detailed viewpoints of combustion. Detailed chemical kinetics has not been included but the results point out which chemical-flow configurations are of interest in turbulent combustion. From detailed or reduced chemical analysis, these specialized simulations could be extended.

Organizer: William T. Ashurst
Sandia National Laboratories, Livermore

10:30 Linear-Eddy Modeling: Concept and Applications
Alan R. Kerstein, Sandia National Laboratories, Livermore

11:00 Pulse Combustion: The Importance of Flame Extinction by Fluid Dynamic Strain
Pamela K. Barr, Sandia National Laboratories, Livermore

11:30 Differential Diffusion Effects in Homogeneous Turbulence
Jacqueline H. Chen, Sandia National Laboratories, Livermore

12:00 Geometry of Premixed Flames in Three-Dimensional Turbulence
William T. Ashurst, organizer

MS2/Long Key Ballroom

Reduced Mechanisms for Combustion Calculations
Reduced mechanisms for combustion applications allow a considerable reduction in computer time and storage. By introducing steady state assumptions for intermediate species the number of the differential equations are considerably reduced. This requires that the proposed mechanism is tested for one-dimensional flames under various conditions of pressure, temperature and equivalence ratios.

The speakers will discuss recent advances in the development of reduced mechanisms, specific formulations, and comparisons with alternative approaches.

Organizer: Norbert Peters, Institut für Technische Mechanik, RWTH Aachen, Germany

10:30 Reduced Mechanisms for Hydrogen and Hydrocarbon Flames
Fabian Mauss, Institut für Technische Mechanik, RWTH Aachen, Germany

11:00 Flamelet Libraries for the Numerical Solution of Complex Turbulent Combustion Problems in Research and Industry
Bernd Rogg, University of Cambridge, United Kingdom

11:30 Prediction of Soot Formation in Laminar and Turbulent Diffusion Flames
Peter Lindstedt, Imperial College, United Kingdom
12:00  Simplification of Chemical Kinetics by Constructing Low-Dimensional Manifolds in Composition Space
Ulrich Maaz, Universität Stuttgart, Germany and Stephen B. Pope, Cornell University

CP1/Palm Room
Droplets and Sprays
Chair: H.A. Dwyer, University of California, Davis

10:30  Counterflow Diffusion Spray Flames using Complex Chemistry
N. Darabiha, F. Lacas and J.C. Rolon, CNRS, École Central Paris, France

10:50  Fuel Droplet Vaporization in an Acoustic Field
A. Duvvuru, C.H. Chiang and W.A. Sirignano, University of California, Irvine

11:10  Numerical Modeling of Liquid Propellant Combustion Instability
Y.M. Kim, Z.J. Chen, and C.P. Chen, University of Alabama, Huntsville

11:30  Numerical Model for Evaporating and Combusting Fuel Sprays
Y.M. Kim, H.M. Shang, and C.P. Chen, University of Alabama, Huntsville

11:50  Distribution of Droplet Mass Fraction in the Entrance Region of a Dispersed Flow in Horizontal Pipes
Xin-sheng Yang and Hubert Mainardi, E.S.E.M. Université d'Orléans, France

12:10  A Critical Evaluation of the Constant Vaporization Damkohler Number Assumption in the Mathematical Analysis of Laminar Spray Diffusion Flames
J.B. Greenberg and N. Sarig, Technion-Israel Institute of Technology, Israel

CP2/Banyan Room
Ignition
Chair: F.L. Dryer, Princeton University

10:30  Comparison of Ignition Phenomena Modelled with Detailed and Simplified Kinetics
T.M. Sloane, General Motors Research Laboratories and P.D. Ronney, Princeton University

10:50  Detailed Numerical Simulation of One-Dimensional Ignition Processes Induced by Hot Spots
G. Goyal, U. Maas, and J. Warnatz, Universität Stuttgart, Germany

11:10  Ignition of Dilute Fuel Sprays Employing Detailed Chemistry
Eva Guthell and Jurgen Warnatz, Universität Stuttgart, Germany

11:30  Computational Study of Laser-Induced Thermal Ignition in Premixed Ethylene-Oxidizer Mixtures
Michael A. Tanoff, Yale University and Chalmers University of Technology, Sweden; Mitchell D. Smooke, Yale University; Jeffrey A. Sell and Richard E. Teets, General Motors Research Laboratories

11:50  Multidimensional Calculation of Spark Flame Initiation and Propagation with a Generic Hydrocarbon Kinetic Scheme
Reinhard Tatschl, Bizhan Ahmadi-Befru and Wilhelm Brandstatter, AVL-List GmbH, Austria
Monday Afternoon, December 2

12:30
Lunch

2:00-4:00
Concurrent Sessions (Minisymposia and Contributed)

MS3/Long Key Ballroom

Japanese Numerical Combustion
The main stream of combustion study in Japan has traditionally been the phenomenological approach based on experimental findings. However, recent remarkable progress in computer software, as well as in the hardware, is going to change this situation. The numerical approach is becoming more and more popular. There are two groups working in this area. The first group is mainly concerned with the chemical kinetics in the simple flow systems, while the second one intends to describe the combustion flow field by adopting simplified kinetics. In this minisymposium, two speakers from the respective groups will provide an overview of their recent studies.
Organizer: Tadao Takeno
Nagoya University, Japan

2:00  Flame Ignition of Premixed Methane Air Mixtures by a High Temperature Body
Taeko Sano, Tokai University, Japan

2:30  Methane-air Premixed Flame Structure by Two-dimensional Simulation
Seishiro Fukutani, Kyoto University, Japan

3:00  Simulation of 3-D Premixed Flame in Engine
Ken Naitoh, NISSAN Motor Co., Ltd., Japan and Kunio Kuwahara, Institute of Space and Astronautical Science, Japan

3:30  Characteristics of Turbulent Fluctuations in Jet Diffusion Flames
Hiroshi Yamashita, Genichiro Kushida and Tadao Takeno, organizer, Nagoya University, Japan

MS4/Jasmine Room

Mathematical Modeling of Fires
Combustion is an essential component in unwanted fires. However, the mathematical modeling of fires requires the study of more phenomena than combustion alone, phenomena such as buoyant convection, heat transfer to surfaces, smoke dynamics, and radiative transfer must be modeled. The purpose of this minisymposium is to describe some of the problems encountered in the modeling of fires and some of the approaches to solving them.

Unwanted fires have long been a substantial and unpredictable drain on human and economic resources. Over the past few decades, mathematical and computational modeling has become an indispensable tool for understanding unwanted fires. Room fires and fires in buildings have been the focus of most modeling. However, large oil spills from tankers, reconsideration of combustion as a means for cleanup, and the massive oil-well fires in Kuwait have brought increased attention to modeling of open fires.
Organizer: Ronald G. Rehm
National Institute of Standards and Technology

2:00  Modeling of Fires
Ronald G. Rehm, organizer, Hai C. Tang, Howard R. Baum, and James S. Sims, National Institute of Standards and Technology
2:30 Fundamentals of Enclosure Fire “Zone” Models  
James G. Quintiere, University of Maryland, College Park

3:00 Applications of Field Modelling of Fires  
I.P. Jones and N.S. Wilkes, Harwell Laboratory, United Kingdom

3:30 The Fluid Dynamics of Large Fires  
Howard R. Baum, National Institute of Standards and Technology

CP3/Palm Room  
Modeling and Algorithms 1
Chair: S.H. Lam, Princeton University

2:00 The Dynamics of Numerics of Nonlinear Source Terms in Reaction-Convection Equations  
Andre Lafon, ONERA-CERT, France and H.C. Yee, NASA Ames Research Center

2:20 Acceleration of a 2-D Combustion Code Using MOSI to Solve the Pressure and Pressure Correction Fields for a SIMPLER Based Algorithm  
Stephen H. Barthelson, Brigham Young University

2:40 Vorticity-Velocity Formulation for Three-Dimensional Steady Compressible Flows  
A. Ern, École Polytechnique, France and Yale University and M.D. Smooke, Yale University

3:00 Parallel Computational Combustion  
William D. Gropp, Argonne National Laboratory and David E. Keyes, Yale University

3:20 Convergent Iterative Methods for Multicomponent Diffusion  
V. Giovangigli, École Polytechnique, France

CP4/Banyan Room  
Detonations 1
Chair: Joseph Shepherd, Rensselaer Polytechnic Institute

2:00 Numerical Simulation of Inviscid Detonation Waves with Finite Rate Chemistry  
Vinh Ton, Ann R. Karagozian, Bjorn E. Engquist and Stanley J. Osher, University of California, Los Angeles

2:20 Higher Order Numerical Simulations of Multi-dimensional Detonation Waves  
Wei Cai and You-lan Zhu, University of North Carolina, Charlotte

2:40 Asymptotic and Numerical Predictions of Oblique Detonations with Simple Finite-Rate Chemistry  
Joseph M. Powers and Matthew J. Grzimer, University of Notre Dame and Shaye Yungster, ICMP-NASA Lewis Research Center

3:00 Detonation in Sprays  
Lionel Sainsaulieu, CERMICS, ENPC, France

3:20 The Speed of Detonation Waves  
Jon K. Tegner, Royal Institute of Technology, Sweden

4:00-4:30/Sabal Room  
Coffee
Concurrent Sessions (Contributed)

CP5/Long Key Ballroom

**Multiphase Combustion 1**

Chair: Michael Delichatsios, Factory Mutual Research Corporation

4:30  A Computational Model of the MOCVD GaAs
R.M. Zurn and M.D. Smooke, Yale University

4:50  The Fluctuation Frequency of Pool Fires: A Simple
Predictive Approach
Ishwar K. Puri, University of Illinois, Chicago and Anthony
Hamins, National Institute of Standards and Technology

5:10  Heat and Mass Transport from Heated Material in a Low
Reynolds Number Microgravity Environment
Hiroshi Yamashita, Howard R. Baum and Takashi Kashiwagi,
National Institute of Standards and Technology and Genichiro
Kushida, Nagoya University, Japan

CP6/Jasmine Room

**Modeling and Algorithms 2**

Chair: Ann Karagozian, University of California, Los Angeles

4:30  Identification of Intermediates and Fast Reactions in
Complex Kinetics Mechanisms Using CSP
D.A. Goussis and S.H. Lam, Princeton University

4:50  A Front-Tracking Scheme with Subcell Resolution
Capability
Charlie H. Cooke and Tze-Jang Chen, Old Dominion
University

5:10  An Advanced Computing Environment for Numerical
Combustion Applications
M. Bernuschi, M. Briscollini, F. Lozupone, M. Maggiore, F.
Papetti, and P. Santangelo, IBM ECSEC, Italy; G. Chlatti, and
S. Golini, Università di Roma, La Sapienza, Italy; and S. Succi,
IBM ECSEC, Italy and Università di Roma, La Sapienza, Italy

CP7/Palm Room

**Detonations 2**

Chair: Martin Sichel, University of Michigan, Ann Arbor

4:30  A Geometric Singular Perturbation Analysis of Detonation
and Deflagration Waves
I. Gasser, C. Schmeiser, and Peter Szmolyan, Technical
University-Wien, Austria

4:50  Detonation Waves and the Front Tracking Method
Bruce G. Bukiet, New Jersey Institute of Technology and
Ralph Menikoff, Los Alamos National Laboratory

5:10  Dynamic Structure of Detonation Front
A.A. Borissov and O.V. Sharypov, USSR Academy of
Sciences, USSR
Tuesday Morning, December 3

8:00/Fountain Courtyard
Registration Opens

8:30/Long Key Ballroom
IP3/Chair: Charles Westbrook, Lawrence Livermore National Laboratory
Modeling Multidimensional Flames
The ability to predict the coupled effects of complex transport phenomena
with detailed chemical kinetics is critical in the modeling of turbulent
reacting flows, in improving engine efficiency, and in understanding the
processes by which pollutants are formed. While the majority of multistep
kinetic flame studies in the literature have been one-dimensional in nature,
recent advances in the development of computational algorithms, reaction
kinetics and mainframe supercomputers can enable the combustion scient-
tist to investigate chemically reacting systems that were computationally
infeasible only a few years ago. In this talk, we focus our attention on one
such system—the axisymmetric laminar flame. We discuss issues related
to the modeling of the fluid dynamic and thermochemistry solution fields
on both serial and parallel computers and we provide an assessment as to
the applicability of partial equilibrium/full equilibrium and reduced chem-
istry submodels.

Mitchell D. Smooke
Department of Mechanical Engineering
Yale University

9:15/Long Key Ballroom
IP4/Chair: Charles Westbrook, Lawrence Livermore National Laboratory
Numerical Simulation of Laminar Reactive Flow
In many laminar or turbulent reactive flows, the effects related to the
compressibility of the gases involved in the combustion process are
important. The development of adequate numerical methods, which remain
robust, efficient and stable for compressible reactive flows at different
regimes is therefore needed.

The emphasis in this presentation will be put on the description of the
available numerical methods for these flows and their applications in a
variety of situations including subsonic premixed or diffusion flames and
supersonic reactive jet interaction.

Bernard Larreaourou
CERMICS, INRIA
Sophia-Antipolis, France

10:00-10:30/Sabal Room
Coffee

10:30-12:30

Concurrent Sessions (Minisymposia and Contributed)

MS5/Long Key Ballroom
Computational and Theoretical Approaches to Supersonic
Reacting Flows
When the energy release or the fluid flow is very fast, shock waves can
develop, fluid-dynamic effects can dominate diffusive phenomena, comp-
ressibility effects in turbulence become important, and detonation waves
may appear. The speakers in this minisymposium will discuss results of
fundamental numerical and theoretical approaches to several different
kinds of supersonic reactive flows. The multidimensional computations of
detonations show basic structures of propagating detonation waves in gas-
phase, condensed-phase, and multiphase media that are important features
to consider for explosive safety and design. The computations of structure
and mixing in reacting and nonreacting supersonic shear flows may
describe astrophysical phenomena and are important in designing efficient
supersonic aircraft.

Organizer: Elaine Oran
U.S. Naval Research Laboratory

10:30 Computation of Multidimensional Supersonic Reacting Flows
Elaine Oran, organizer

11:00 Numerical Modeling of Heterogeneous Detonations
Martin Sichel, University of Michigan, Ann Arbor

11:30 Large-Eddy Simulation of Supersonic Shear Layers
Bakhiet Farouk, Drexel University

12:00 Mixing Enhancement of Reacting Parallel Fuel Jets in a Supersonic Flow Field
J. Philip Drummond, NASA Langley Research Center

CP8/Banyan Room
Multiphase Combustion 2
Chair: Howard R. Baum, National Institute of Standards and Technology

10:30 Mathematical Model for Smoldering Combustion
John C. Edwards, U.S. Department of the Interior

10:50 Effect of Radiation on the Flame Stabilization Over a Solid Fuel Plate
Seung Wook Baek and Jeong Soo Kim, Korea Advanced Institute of Science and Technology, Korea; and Carolyn R. Kaplan, Naval Research Laboratory

11:10 A Hydrodynamic Stability Analysis of Wind-Aided Flame Spread Across a Ceiling
Sanjay Agrawal and Indrek S. Wichman, Michigan State University

11:30 Asymptotic, Approximate and Numerical Solutions for the Transient Heat-up, Ignition and Pyrolysis of Burning Materials Including Reradiation Losses
Michael A. Delichatsios and Yonggang Chen, Factory Mutual Research Corporation

11:50 Particle Mixing for Combustion
Mori L. Mittal, Ohio Supercomputer Center and Urmila Chhia, University of Cincinnati

12:10 Numerical Count of Temperature Structure of Wave SHS in System with Complex Form
Aleksi Gennadievich Terekhov and Victor Deamidovich Gladun, Institut Metallurgii i Obogashchenia AN Kaz SSR, USSR

CP9/Jasmine Room
Laminar Diffusion Flames
Chair: Jurgen Warnatz, Universitaet Stuttgart, Germany

10:30 Velocity Effects on the Dynamic Behavior of the H2-N2 Diffusion Flame
K. Viswanath Reddy and W.M. Roquemore, Wright Laborator-
ries/POSF

10:50 A Numerical/Experimental Investigation of the Dynamic Structure of a Buoyant Jet Diffusion Flame
R.W. Davis and E.F. Moore, National Institute of Standards and Technology; L-D. Chen, University of Iowa; W.M. Roquemore, WRDC/Aero Propulsion Laboratory; and L.P. Gos, Systems Research Laboratories, Inc.

11:10 A Numerical Study of an Ethylene Diffusion Flame
Carolyn R. Kaplan, Naval Research Laboratory; Seung W. Baek, Korea Advanced Institute of Science and Technology; Korea; Janet L. Elizay, University of Texas, Austin; and Elaine S. Oran, Naval Research Laboratory

11:30 Primitive Variable Solution of a Confined Laminar Diffusion Flame Using a Detailed Reaction Mechanism
Yuenong Xu and Mitchell D. Smooke, Yale University

11:50 A Numerical Study of the Leading Edge of Laminar Diffusion Flames
Kaldeep Prasad, Robert K. Sigman, and Edward W. Price, Georgia Institute of Technology

12:10 Numerical Simulation of the Ignition of a Diffusion Flame Rolled-Up in a Vortex
Dominique Thevenin and Sebastien Candel, École Centrale Paris, France

CP10/Palm Room
Turbulence 1
Chair: Julian Tishkoff, Air Force Office of Scientific Research

10:30 Turbulent Reactive Gaseous Jet Flow in an Axisymmetric Enclosure
Parrokh Issac, Ann R. Kanggozian, and Owen I. Smith, University of California, Los Angeles

10:50 Numerical Simulation of a Premixed V-Shaped Flame
B. Roche, G. Brun and D. Escudie, École Central de Lyon, France

11:10 A Linear Eddy Flamelet Subgrid Model for Large-Eddy Simulations of Turbulent Premixed Combustion
Suresh Menon, QUEST Integrated, Inc.; Patrick A. McMurtry, University of Utah; and Alan R. Kerstein, Sandia National Laboratoires

11:30 A Linear Eddy Sub-Grid Model for Turbulent Mixing and Reaction
Patrick A. McMurtry, University of Utah; Suresh Menon, Quest Integrated, Inc.; and Alan R. Kerstein, Sandia National Laboratoires

11:50 Investigation of the Mixture Fraction PDF
William Mell, George Kosaly, and James J. Riley, University of Washington

12:10 Influence of Turbulence on a Flame Kernel
Elna M.B. Holmgren, Royal Institute of Technology, Sweden
Tuesday Afternoon, December 3

12:30

Concurrent Sessions (Minisymposia and Contributed)

MS6/Banyan Room

Numerics and Asymptotics: A Symbiotic Approach to
Detonation Physics

The theme of the minisymposium is the notion that numerics is at its most reliable when aided, inspired, or guided by analysis. The speakers will describe recent and ongoing work that subscribes to this premise and explores, via a complementary analytical/numerical approach, the topics of detonation structure, evolution and propagation. The presentation by Dold will concentrate on numerical methods designed to capture, accurately and reliably, transient features that always seem to participate in evolution towards detonation. Shepherd will present numerical computations of detonation structure based on the ZND model, including detailed kinetics and realistic thermochemical properties, and compare the results with those of simplified models. Bdzil will discuss the numerical implementation of the Bdzil-Stewart Detonation-Shock-Dynamics theory for realistic geometries, and describe how the results compare with actual observations.

Organizer: Ashwani Kapila
Rensselaer Polytechnic Institute

2:00   Numerical Verification of Asymptotic Predictions
Concerning Detonation Initiation
J.W. Dold, University of Bristol, United Kingdom and Ashwani Kapila, organizer

2:30   Numerical Analysis of Detonation Structure
Joseph E. Shepherd, Rensselaer Polytechnic Institute

3:00   Two-Dimensional Detonation Front Tracking: A Comparison of Asymptotic and Numerical Modeling and Experimental Observation
J.B. Bdzil, Los Alamos National Laboratory

3:30   Additional speaker and title to be announced.

MS7/Palm Room

Modelling and Simulation of Time-Dependent Combustion Phenomena

Real-life combustion is an instationary, three-dimensional, turbulent phenomenon. Whilst an appreciable amount of theoretical, numerical and experimental research has been devoted to the complex subject of statistically stationary turbulent flows, relatively little attention has been given to the modelling and simulation of time-dependent, multi-dimensional, laminar or turbulent, chemically reacting flows. It is the purpose of this minisymposium to report on the progress of and, thereby, to stimulate further interest in the modelling and simulation of both laminar and turbulent multidimensional combustion phenomena.

The numerical solution of combustion problems usually requires the solution of large non-linear systems of equations. The general approach to the solution of the non-linear systems is to linearize them, for instance, by Newton's methods. Sophisticated linear-algebra software is required to solve the linear systems of equations.

Organizer: Bernd Roeg
University of Cambridge, United Kingdom
2:00 Modelling and Simulation of Time-Dependent Combustion Phenomena
Bernd Rogg, organizer

2:30 Domain-Adaptive Techniques for Two-Dimensional, Time-Dependent Chemically Reactive Flows
J.I. Ramos, Carnegie-Mellon University

3:00 Detailed, Transient, Two-Dimensional Simulations of Laminar Flame Structures in Lean Hydrogen-Air Mixtures
Gopal Patnaik, U.S. Naval Research Laboratory

3:30 Unsteady Dynamics of Boundaries Between Burning and Non-Burning
J.W. Dold, University of Bristol, United Kingdom

CP11/Jasmine Room
Laminar Premixed Flames 1
Chair: Arje Nachman, Air Force Office of Scientific Research

2:00 Modeling of Microgravity Combustion Phenomena
John Buckmaster, University of Illinois, Urbana

2:20 Premixed Flame Stability in a Stagnation Flow to General Disturbances
Moshe Matalon, Northwestern University and T.L. Jackson, Old Dominion University

2:40 The Response of Premixed Flames to Temporally Periodic Straining Flows
David W. Mikolaitis, University of Florida

3:00 Analytical Solution of a Near-Equidiffusional Flame Problem
Glenn Ledder, University of Nebraska, Lincoln

3:20 Pressure Wave Steepening in Premixed Flame-Pressure Pulse Interactions
A.C. McIntosh, G. Batley, and J. Brindley, Leeds University, United Kingdom

CP12/Long Key Ballroom
Turbulence 2
Chair: Sebastien Cantel, École Central Paris, France

2:00 A Combustion Model for Incompressible Flows
Maria E. Calzada, Loyola University

2:20 A Random Choice Method with a Dictionary Approach for Turbulent Combustion
Yu Song, Tulane University

2:40 Turbulent Flames Close to Extinction: A Discussion in Context of the Flamelet Theory
Ishwar K. Puri, University of Illinois, Chicago

3:00 Turbulent Flames Close to Extinction. Part II: Survival Probability During Random Walks
Ishwar K. Puri, University of Illinois, Chicago

3:20 Numerical Modelling of Three-Dimensional Flows within the Cylinder of a Direct Injection Diesel Engine
Alberto A. Boretti and M.G. Lisbona, FIAT Research Center, Italy

3:40 Numerical Modelling of Three-Dimensional Flows within the Cylinder of a 4 Valve Spark Ignition Engine
Alberto A. Boretti and M.G. Lisbona, FIAT Research Center, Italy
Concurrent Sessions (Contributed)

CP13/Palm Room
Supersonic Combustion
Chair: M.Y. Hussaini, ICASE-NASA Langley Research Center

4:30 The Thermodynamical Behavior in the Optimization of Supersonic Combustor for Some Flight Regimes
Carlos Frederico Estrada Alves, Polytechnic Institute of Rio de Janeiro, Brazil; Leon R. Sinay, Institute for Space Research, Brazil; and Demetrio Bastos-Netto, Institute for Space Research and University of California, San Diego

4:50 Computation of Oscillating Shock-Induced Combustion Observed in Ballistic-Range Experiments
Gregory J. Wilson and Myles A. Sussman, Stanford University

CP14/Jasmine Room
Laminar Premixed Flames 2
Chair: V. Giovangigli, École Polytechnique, France

4:30 A Numerical Simulation of the Rayleigh-Taylor Instability in Premixed Flame Propagation
A.C. McIntosh, F. Liu, and J. Brindley, Leeds University, United Kingdom

4:50 The Mass Burning Rate Response of a Premixed Flame to Sharp Pressure Changes
A.C. McIntosh, Leeds University, United Kingdom

5:10 Flame Extinction in Models of Laminar Flames
Joth D. Avrin, University of North Carolina, Charlotte and James F. Epperson, University of Alabama, Huntsville

CP15/Long Key Ballroom
Turbulence 3
Chair: Thierry Poinsot, École Centrale de Paris, France

4:30 Simulation of Combustion and NOx Formation in Gas- and Oil-Fired Furnaces
G. De Michele and S. Malloggi, ENEL-Centro Ricerche Termiche e Nucleari, Italy; S. Merlini, MATEC, Milano, Italy; and S. Pasini, ENEL-Centro Ricerche Termiche e Nucleari, Italy

4:50 Modeling of Combustion Processes in an Industrial Furnace Fired by Oxy-Fuel Burners
Bakhitier Farooq and Christopher J. McKenna, Drexel University

5:10 Modeling of Sulphur Plant Reaction Furnace
Mark K.Y. Lai, National Research Council Canada
Wednesday Morning, December 4

8:00/Fountain Courtyard
Registration Opens

8:15/Long Key Ballroom
Closing Remarks

8:30/Long Key Ballroom
IP5/Chair: Elaine Oran, U.S. Naval Research Laboratory
Numerical Simulation of Several Reacting Gasdynamic Phenomena
The speaker will focus on stiff problems of chemically reacting flows with exothermicity. He will discuss computational aspects like grid generation, and accuracy of numerical techniques, and physical interpretations of numerous interesting phenomena like multiple Mach reflections and galloping in self-sustaining detonations. The problems he will address include three-dimensional detonation propagating in a circular tube, laser-supported detonation in hydrogen/air, oblique detonation in oxyhydrogen mixtures, reacting shear layer and its development into turbulent flame, and three-dimensional structure of shear layer.
Toshi Fujiiwara
Department of Aeronautical Engineering
Nagoya University, Japan

9:15/Long Key Ballroom
IP6/Chair: Elaine Oran, U.S. Naval Research Laboratory
Successes and Failures in Numerical Simulation of Gas-Turbine Combustion
To be useful in practice, combustion models must predict parameters such as efficiency, NOx, CO and SOx emissions, and life. Physico-chemical modeling and numerical techniques are not yet advanced enough, however, to address all relevant issues.
The speaker will present examples of success and failure in the numerical simulation of gas-turbine combustion. For example, the k-ε assumed shape pdf/fast chemistry model is adequate for gross velocity and temperature fields and for thermal NOx in non-premixed 3D combustors. Stirred flow reactors can predict NOx in lean intensely turbulent premixed flames, but CO and hydrocarbons involve intimate interaction between kinetics and chemistry and are not predicted well. Unsteady models are needed to account for dynamics. Even though a single comprehensive code does not exist models are making an impact.
Sanjay M. Correa
General Electric Research Center

10:00-10:30/Sabal Room
Coffee

10:30-12:30
Concurrent Sessions (Minisymposia and Contributed)

MS8/Palm Room
Droplet and Spray Analysis
Spray combustion science is relevant to many power and propulsion applications where liquid fuel is directly injected into a combustion cham-
ber. Computational fluid dynamics is becoming more important in the study of this two-phase flow phenomenon. The minisymposium will cover vital computational issues concerning interacting droplets, transient heating and vaporization, radiative heating of droplets, chemical reaction in the gas film surrounding droplets, and internal liquid circulation. Numerical methods and results concerning detailed flow, thermal, and compositional fields within and around vaporizing droplets will be discussed.

Organizer: William A. Sirignano
University of California, Irvine

10:30  A Study of Droplet Spray Combustion by Numerical Simulation
R. Borghi and S. Loison, University of Rouen, France

11:00  Mathematical Modeling of Droplet Combustion
S.Y. Cho and F.L. Dryer, Princeton University

11:30  Droplet Ignition Calculations with Detailed Chemistry
H.A. Dwyer, University of California, Davis

12:00  Numerical Computations of Droplet Vaporization Including Radiation Absorption Effects
R.H. Rangel and P.L. Lage, University of California, Irvine

Numerics and Asymptotics: Some Basic Models in High Speed Propulsion
The focus of this minisymposium is on some basic models in high speed propulsion. Each model presented employs a combination of asymptotic and numerical methods, and the need for this dual approach is emphasized. These models, currently under investigation at NASA Langley Research Center, are designed to aid in the understanding of basic physical phenomena for either the SCRAMJET Engine or the Oblique Detonation Wave Engine (ODWE). Since compressibility cannot be neglected, this area of research continues to provide a challenge for mathematical modelers trying to understand the interaction between hydrodynamic and combustion processes.

The National Aerospace Plane (NASP) project has brought out the need for understanding combustion phenomena in supersonic and hypersonic flows where compressibility effects peculiar to such flows cannot be neglected. There has been practically no theory of ignition, flame structure, stability and propagation in these flows owing to the absence of physical models that are simple enough for analytical approach while simulating numerically observed phenomena. This minisymposium is designed to encourage the development of such models.

Organizer: Thomas L. Jackson
Old Dominion University

10:30  Ignition and Structure of Diffusion Flame-Vortex Interactions
Michele G. Macaraeg, NASA Langley Research Center; Thomas L. Jackson, organizer and M.Y. Hussaini, ICASE, NASA Langley Research Center

11:00  Disturbance Patterns Associated with an Oblique Detonation Wave
D. Glenn Lasseigne, Old Dominion University and M.Y. Hussaini, ICASE, NASA Langley Research Center

11:30  Absolute/Convective Instabilities in a Compressible Mixing Layer with Finite Rate Chemistry
Chester E. Grosch, F.Q. Hu, and Thomas L. Jackson, organizer
12:00 Vorticity/Detonation Wave Interactions
Thomas L. Jackson, organizer and D. Glenn Lasseigne, Old Dominion University and M.Y. Hussaini, ICASE, NASA Langley Research Center

12:30 Numerical Simulation of Shock-Induced Combustion/Detonation in a Premixed H2-Air Mixture
Dal J. Singh, Analytical Services and Materials Inc.; Mark H. Carpenter and Ajay Kumar, NASA Langley Research Center

CP16/Jasmine Room
Laminar Premixed Flames 3
Chair: M. Bikan, Air Force Office of Scientific Research

10:30 Premixed-Flame Propagation in Spatially Periodic Shear Flow
Ralph Curtis Aldredge, III, California Institute of Technology and Forman A. Williams, University of California, San Diego

10:50 A Computational Study of Methane/Air Combustion Above a Heated Catalytic and Non-Catalytic Flat Plate
Penelope Markatou, Pennsylvania State University; Mitchell D. Smooke and Lisa D. Pfefferle, Yale University

11:10 Numerical Modeling of Flame Extinction in Shear Flow
Gregory Kosalovsky and G.I. Sivashinsky, City College of The City University of New York

11:30 Numerical Simulation of Axisymmetric Premixed Bunsen Flames
V. Giovangigli, École Polytechnique, France and Mitchell D. Smooke, Yale University

11:50 An Unstructured Navier-Stokes Solver for Laminar Combustion
Alan C. Mueller, QUEST Integrated, Inc.

12:10 Vortex Driven Modifications of the Structure of Premixed Flames with Non-Unity Lewis Number
Arnaud Trouve, Stanford University and Thierry Poinset, École Centrale de Paris, France

CP17/Long Key Ballroom
Turbulence 4
Chair: Alan R. Kerstein, Sandia National Laboratories, Livermore

10:30 Fractal Numerics in Turbulent Combustion
Mazda A. Marvasti and Warren C. Strahl, Georgia Institute of Technology

10:50 Incinerator Modeling Emphasizing Detailed Chemistry
Robert B. Barat, New Jersey Institute of Technology

11:10 Flame Surface Statistics by Direct Numerical Simulation
Robert Stewart Cant, UMIST, United Kingdom

11:30 Using Numerical Simulation to Study Flamelets in Premixed Turbulent Combustion
Thierry Poinset, École Centrale Paris, France; Arnaud Trouve, Center for Turbulence Research; Daniel Haworth, General Motors Research Laboratory; and Christopher Rutland, University of Wisconsin, Madison

11:50 Using Numerical Simulation to Study the Ignition of Flames in Premixed Turbulent Flowfields
Markus Baum and Thierry Poinset, École Centrale Paris, France
Wednesday Afternoon, December 4

12:30

Lunch

2:00-4:00

Concurrent Sessions (Minisymposia and Contributed)

MS10/Palm Room (2:00-5:30 PM)

Comparison of Numerical Methods for Detonation Simulations

The minisymposium will focus on quantitative comparisons among numerical methods for the reacting Euler equations in one and two dimensions. These methods include Godunov-based methods, front tracking, adaptive Lagrangian, and piecewise parabolic interpolation. The minisymposium participants have agreed to make calculations on a common set of problems simulating detonation, so that detailed comparisons can be made in a standard format. A goal of this minisymposium is to make progress towards establishing a standardized test suite for Euler codes with chemical reaction, similar to collections of analytical and numerical test problems used for verification in more mature computational disciplines. Since recent progress has been made in comparisons of numerical simulations to linear stability results for detonation, there is interest in trying to understand the broader implications of stability results for predicting nonlinear detonation evolution.

Organizer: D. Scott Stewart
University of Illinois, Urbana

2:00  Simulation of Detonation with CAVEAT and CMHOG
D. Scott Stewart, organizer and James Stone, University of Illinois, Urbana

2:30  A New High Resolution Numerical Method for Detonation Calculations
Anne Bourlioux and Andrew Majda, Princeton University

3:00  Nonlinear Development of Detonation Instabilities
Victor Roytburd, Rensselaer Polytechnic Institute and Andrew Majda, Princeton University

3:30  One and Two Dimensional Detonation Simulations at INRIA
Didier Chalot and Bernard Larrouquere, CERMICS, INRIA, Sophia-Antipolis, France

4:00  Session will break for coffee

4:30  Simulations of Unsteady Detonation Waves
Tasso Lappas, Anthony Leonard and Paul E. Dimotakis, California Institute of Technology

5:00  Test Suite Standardization for the Reactive Euler Equations
Michael Norman, University of Illinois, Urbana

MS11/Long Key Ballroom

Turbulent Combustion

Because of its importance in engineering applications, turbulent combustion continues to be an important research topic. In this minisymposium, recent work using two different computer-intensive techniques is described. In the first technique, direct numerical simulation (DNS), conservation equations are solved for the three-dimensional transient fields describing simple turbulent reactive flows. There are no modelling as-
sumptions, there is no difficulty in extracting information from the solution, but computation capacity places severe restrictions on the parameter range that can be studied. In the second technique, PDF methods, a modelled evolution equation for the joint pdf of flow variables is solved by Monte Carlo.

Organizer: Stephen B. Pope
Cornell University

2:00 Numerical Issues in PDF Methods
Stephen B. Pope, organizer

2:30 PDF Modeling of Turbulent Nonpremixed Jet Flames
J.-Y. Chen, Sandia National Laboratories, Livermore

3:00 DNS and Multidimensional Modeling: Complementary Tools for Investigating Turbulent Combustion in IC Engines
Daniel C. Haworth, General Motors Research Laboratories

3:30 Direct Numerical Simulation of Turbulent Premixed Flames
Thierry Poinso, École Central de Paris, France

CP18/Jasmine Room
Laminar Premixed Flames 4
Chair: David W. Mikolaitis, University of Florida

2:00 Evaluation of Chemical Kinetic Models for Hydrogen Air Combustion
K.M. Isaac, University of Missouri, Rolla

2:20 Kinetic Simulations of the Formation of Chlorinated Organics in a Medical Waste Incinerator
Craig Salcic, John Wagner, Mitchell Goodman, and Alex Green, University of Florida

Raymond C.Y. Chin and Richard Y. Tam, Indiana University-Purdue University, Indianapolis

3:00 A Hybrid Asymptotic-Numerical Method for the Flame Propagation Problem II: Multi-step, Plane Flame
Raymond C.Y. Chin and Richard Y. Tam, Indiana University-Purdue University, Indianapolis

4:00-4:30/Sabal Room
Coffee

4:30-5:30
Concurrent Sessions (Contributed)

CP19/Banyan Room
Multiphase Combustion 3
Chair: Ishwar K. Puri, University of Illinois, Chicago

4:30 Unsteady Diffusion Mass Transfer in Circulating Fluidized Beds
P. Zamankhan, Valtion Teknillinen Tutkimuskeskus, Finland

4:50 The Fractal Nature in Condensed Phase of the Temperature and Concentration Profiles in Reaction Front
Aleksei Gennadievich Terekhov and Victor Deamidovich Gladun, Institut Metallurgii i Obogashenia AN Kaz SSR, USSR

5:10 Numerical Modeling Wave of Combustion in Solid
Aleksei Gennadievich Terekhov and Victor Deamidovich Gladun, Institut Metallurgii i Obogashenia AN Kaz SSR, USSR
Laminar Premixed Flames 5

Chair: Peter Lindstedt, Imperial College, United Kingdom

4:30 Application of Continuation Methods to Plane Premixed Laminar Flames
V. Giovangigli, Ecole Polytechnique, France and Mitchell D. Smooke, Yale University

4:50 Numerical Simulation of Laminar Flames

5:10 Upstream Interactions Between Two Laminar Premixed Methane Flames
C.L. Chen and S.H. Sohrab, Northwestern University

Turbulence 5

Chair: Stewart Cant, UMIST, United Kingdom

4:30 Direct Simulation of Turbulent Variable Density Premixed Flames
Christopher J. Rutland and Songwei Zhang, University of Wisconsin, Madison

4:50 Direct Numerical Simulation of Turbulent Diffusion Flames with Multi-step Chemistry
Nedunchezhan Swaminathan and Shankar Mahalingam, University of Colorado, Boulder

5:10 3D Direct Numerical Simulations of Turbulent Reactive Flows
J.P. Chollet, R.J. Gathmann, Institut de Mecanique de Grenoble, France

5:30 Conference Adjourns
TRANSPORTATION

Official Carrier for Continental USA and Canada

American Airlines (logo) is the official carrier for this conference. In a special arrangement for this conference, you can fly to Tampa at a discounted rate from November 29 - December 7, 1991 inclusive.

For those attendees traveling from points in the United States, American Airlines is offering a 45% discount off regular day coach airfares. For those in Canada, the discount is 35%. Each rate requires seven (7) days advance purchase.

You may be able to obtain an even lower airfare. American Airlines also is offering a five percent (5%) discount off any published airfare (including First Class and Ultra Saver fares) for which you qualify, i.e., you must satisfy all rules and restrictions on the fares quoted. Discounts can range from 40% to 70% off regular coach fares.

To make reservations for either of the above discounted fares:

- Call the American Airlines Convention Desk at the toll free number 800-433-1790 seven days a week from 8:00 AM to 11:00 PM (EST). Be sure to mention the SIAM Account Number S07Z1CN. American Airlines will mail your ticket to your home or office.
- You may use your corporate or university travel agent to purchase your ticket. Your agent should call the American Airlines Convention Desk to make your reservation. Make sure your agent mentions the discounts and uses the SIAM Account Number: S07Z1CN.

From Outside Continental USA and Canada

There is no designated carrier from foreign countries to the United States as each country has its own rules and regulations for airfares.

Reminder: When available, you can save money by buying an APEX ticket, but you generally must purchase your ticket at least three weeks (21 days) in advance of your departure date and stay in the United States at least seven days but not longer than two months.

PUBLIC TRANSPORTATION

The airport is approximately 30 to 40 minutes from the hotel. There are two shuttle services available that run 24 hours a day and can be taken from outside the baggage claim areas of the airport. They are Limousine Incorporated and Airport Connection. Both van services run approximately $12.00 per trip. You can purchase a round trip ticket for $22.00.

There are a number of cab companies that service the airport. The average one-way cost from the airport to the hotel is $50.00.

Driving Directions from Tampa International Airport

When exiting the airport take 275 South to exit #4 which is the Pinellas Bay exit (approximately 20 minutes). Take Pinellas Bay to Gulf Blvd. (approximately 10 minutes). Turn right on Gulf Blvd., the hotel is on Gulf Blvd. two miles from the turn on the left.

Attractions within driving distance of the hotel

- Busch Gardens - 45 minutes
- Adventure Island - 45 minutes
- Sea World, Disney's Magic Kingdom and Epcot Center, MGM Studios and Pleasure Island - 2 hours
- Cypress Garden - 1 1/2 hours
- Salvador Dali Museum - 20 minutes
- Ringling Museum - 50 minutes
CAR RENTAL

Car Rental at the Airport or On-site at TradeWinds Hotel

Avis Rent-a-Car is the official car rental agency for this conference. Attendees may pick up and return cars at any corporate Avis rental location throughout the state of Florida at no additional charge. Conveniently, attendees can pick cars up at the airport location and on-site at the hotel. The rates are subject to the conditions listed below. Should a special rate be offered during the time of this conference, Avis will extend this rate to you. The rates listed below are the maximum rates you can expect to pay.

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</thead>
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<tr>
<td>Subcompact</td>
<td>$23.90</td>
<td>$89.00</td>
</tr>
<tr>
<td>Intermediate</td>
<td>$29.90</td>
<td>$129.00</td>
</tr>
<tr>
<td>Mini Van, Luxury or Convertible</td>
<td>$39.90</td>
<td>$199.00</td>
</tr>
</tbody>
</table>

Conditions for Car Rental

(1) Unlimited free miles

(2) Rates are valid from November 25 - December 11, 1991 inclusive and are available at the airport and on-site at the hotel. Cars do not have to be picked up and dropped off at the same location. You may rent a car at the airport and drop it off at the hotel or vice versa.

(3) You must be 21 years of age and have a valid U.S. or International Drivers License.

(4) You must have one of the following credit cards to rent a car: American Express, MasterCard, Visa, or Diner's Club.

(5) The prices quoted do not include refueling services, tax, optional collision and loss damage waiver (CDW and LDW), or optional personal accident insurance.

Reservations

We encourage you to make advanced reservations, as on-site availability cannot be guaranteed. Make reservations by calling 800-331-1600. When making your reservations, be sure to give the SIAM Rate Code AW022721. You should also mention that you are attending the SIAM Conference on Combustion, December 2-4, 1991 in St. Petersburg, in order to receive the indicated rates. You must also specify if you will pick up the car at the airport or at the hotel.
HOTEL INFORMATION

TradeWinds Hotel
5500 Gulf Boulevard
St. Petersburg Beach, FL 33706
813-367-6461

Reservations: SIAM is holding a block of rooms at the TradeWinds Hotel on a first come first served basis at the specially discounted rates of $85.00 single, $95.00 double and $125.00 for a one or two bedroom suite. Please note that all rates are subject to an occupancy tax of 10%. These rooms will be held for our exclusive use until November 2, 1991, after which reservations will depend on availability. SIAM cannot guarantee any assistance in getting you a room at the hotel if you choose to make your reservations after the November 2nd deadline. A deposit in the amount of one night's room rate is required to confirm reservations. If you need to cancel your reservation, please do so 48 hours prior to the date of your arrival to avoid being penalized.

We urge you to make your reservations as soon as possible. You may do so by telephoning 813-367-6461 or by using the Hotel Reservation Form on the inside back page of this program (domestic mail only). When making reservations, you must identify yourself as an attendee at the SIAM Conference on Combustion to obtain the discounted rate.

Late Arrival Policy: If you plan to arrive after 6:00 PM you must inform the TradeWinds of your plans and guarantee your reservation with a credit card or check in the amount of one night's room rate. If you do not guarantee your room for late arrival and you arrive after 6:00 PM your room may be given to someone else.

Check In: Check-in time is 4:00 PM and check out is 11:00 AM.

Facilities: The TradeWinds guest rooms are housed in a six story contemporary design which features plenty of open outside areas. Thoughtful amenities such as a wet bar, refrigerator, coffee maker, (and, of course, a television and phone in the bathroom) are standard touches in every hotel room. Suites, with one or two bedrooms, offer a separate living area, fully-equipped kitchen and private balconies with spectacular views.

Recreation: The TradeWinds is located next to the warm waters of the Gulf of Mexico on seven miles of white sand. This offers limitless choices for leisurely activities such as sailboating, water skis, kayaks, windsurfing, tennis, basketball, ping pong, bicycle rental, aerobics, and game rentals. Within a five- and ten-minute walk, you can find jet skiing and water skiing facilities. You can also find paddleboat rentals, four pools (one is enclosed), whirlpools, sauna, and a fitness center right at the TradeWinds. There are also daily scheduled activities throughout the hotel for children between the ages of three and early teens.

Restaurants and shopping: Within walking distance of the TradeWinds, there are many little shops and beach bars. At the TradeWinds, there are three locations where you can eat: the Palm Court, which serves breakfast and lunch then in the evening becomes the hotel's fine dining restaurant; the Flying Bridge, a beach bar that serves quick snacks and sandwiches; and Silas Dent, a contemporary restaurant located across the street that will let you charge to your hotel room.

Parking: There is complimentary parking to all hotel guests and those commuting to the conference.
REGISTRATION INFORMATION

Please complete the Advance Registration Form on the inside back cover and return it in the envelope provided. We urge attendees to register in advance to take advantage of the lower registration fee. Advance registration must be received by November 25, 1991.

The registration desk will be open as listed below:

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday, December 1</td>
<td>6:00 PM - 9:00 PM</td>
</tr>
<tr>
<td>Monday, December 2</td>
<td>7:30 AM - 4:30 PM</td>
</tr>
<tr>
<td>Tuesday, December 3</td>
<td>8:00 AM - 4:30 PM</td>
</tr>
<tr>
<td>Wednesday, December 4</td>
<td>8:00 AM - 2:00 PM</td>
</tr>
</tbody>
</table>

### Registration Fees

<table>
<thead>
<tr>
<th></th>
<th>SIAM Member</th>
<th>Non-Member</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advance</td>
<td>$140</td>
<td>$170</td>
<td>$35</td>
</tr>
<tr>
<td>On-Site</td>
<td>$170</td>
<td>$210</td>
<td>$35</td>
</tr>
</tbody>
</table>

### Notice

There will be no prorated fees. No refunds will be issued once the conference has started.

If SIAM does not receive your Advance Registration payment by November 25, 1991, you will be asked to give us a check or a credit card at the conference. We will not process either until we have ascertained that your registration payment has gone astray. In the event that we receive your payment after November 25, 1991, we will destroy your check or credit card slip.

### Credit Cards

SIAM accepts VISA, MasterCard and American Express for the payment of registration fees and special functions. When you complete the Advance Registration Form, please be certain to indicate the type of credit card, the number, and the expiration date.

### SIAM Corporate Members

Non-member attendees who are employed by the following institutions are entitled to the SIAM Member rate.

- Aerospace Corporation
- Amoco Production Company
- AT&T Bell Laboratories
- Bell Communications Research
- Boeing Company
- BP America
- Cray Research, Inc.
- E.I. du Pont de Nemours & Company
- Eastman Kodak Company
- Exxon Research and Engineering Company
- General Motors Corporation
- GTE Laboratories, Inc.
- Nederlandse Signaalapparaten B.V.
- IBM Corporation
- ICASE
- IMSL, Inc.
- Lockheed Corporation
- MacNeal-Schwendler Corporation
- Martin Marietta Energy Systems
- Mathematical Sciences Research Institute
- NEC Research Institute
- Supercomputing Research Center, a division of Institute for Defense Analyses
- Texaco Inc.
- United Technologies Corporation
HOTEL RESERVATION FORM

Fourth International Conference on
Numerical Combustion

December 2-4, 1991
TradeWinds Hotel
St. Petersbug Beach, Florida 33706

PLEASE SEND ME A CONFIRMATION NOTICE
Specially discounted rooms are being held for our exclusive use until November 2, 1991. After that date reservations will depend on availability. Your reservation is not confirmed until acknowledged in writing by the hotel or verified by phone. When making reservations by phone, be certain to identify yourself as an attendee at the Fourth International Conference on Numerical Combustion. Telephone: 813-367-6461.

PLEASE PRINT
Name

Phone
Address
City State Zip

Please reserve [ ] Single $85 [ ] Double $95

[ ] One bedroom suite $125 [ ] Two bedroom suite $125

Arrival Date Arrival Time

Departure Date

I will share a room with

I am a [ ] Smoker [ ] Non-Smoker

I need a double room with [ ] 1 bed [ ] 2 beds

To make a reservation you must include a deposit in the amount of the first night's room rate.

I choose to pay by: [ ] AMEX [ ] VISA [ ] MC [ ] Check

Credit Card No.

Exp. Date Deposit $ Signature

*Please enclose this form in an envelope and mail to Reservation:
TradeWinds Hotel, 5500 Gulf Blvd., St. Petersburg Beach, Florida 33706