

# Supersonic Combustion Modeling and Simulation for Scramjets

By

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## ABSTRACT

In this talk, we will present what we believe is the state-of-the-art of the numerical modeling and simulation of the combustion processes as they relate to typical scramjet engines. The free-stream Mach number is hypersonic, but the speed is not sufficiently decelerated at the inlet/isolator, as in ramjets, so that combustion takes place under supersonic conditions. This creates some difficulties for most turbulence-combustion models. We delve into the details of these problems, by discussing the software programs that have a long track record for scramjet combustion simulation; with a focus on the accuracy of the baseline numerical methods used, the turbulence modeling/simulation approach, the comparative fidelity of the turbulence-combustion interaction models, ability to simulate premixed/non-premixed/partially-premixed, quenching/re-ignition capabilities, the numerical spark-plug method, Damkholer number regimes supported, and the effects of variable Prandtl, Schmidt, and Lewis numbers. Validation results from high-speed and low-speed combustion applications will also be presented.

## BIOGRAPHICAL SKETCH

Dr. Ladeinde received the **B. Sc.** degree from the Faculty of Technology, University of Ibadan, with **First Class Honours**. He moved to the United States in 1981. Since then, he has earned several post-graduate degrees at Cornell University, Ithaca, New York, including his **Ph.D.** in Mechanical and Aerospace Engineering in 1988. He worked for several years as a **high-performance computing (HPC) software developer** before joining the faculty of the **State University of New York (Stony Brook University)**, Stony Brook in 1991 as an Assistant Professor of Mechanical Engineering, where he has since been promoted and tenured. Dr. Ladeinde is a **Visiting Professor** and a **Faculty Fellow** of the **United States Air Force** and the **United States National Research Council**, and a **Visiting Scientist** at the **United States Department of Energy** at the Brookhaven National Laboratory. He is a **Fellow** of the **American Society of Mechanical Engineers (ASME)** and a **Life Member** and an **Associate Fellow** of the **American Institute of Aeronautics and Astronautics (AIAA)**. Dr. Ladeinde **chaired the External Review Board** of the NASA Center for Aerospace Research at North Carolina (NC) A&T University in Greensboro, NC. Dr. Ladeinde founded **TTC Technologies, Inc.** in 1993, an **advanced engineering, education, and enterprise software** company which has been a major contractor for the **United States Department of Defense** for more than 17 years. Dr. Ladeinde has produced over **250 publications** in internationally-recognized **archival journals** and **peer-reviewed conference proceedings**. He has served as an **Associate Editor** (2009-2013) of the **AIAA Journal**, the flagship journal of the AIAA, and is currently an **Associate Editor** of **The ASCE Journal of Aerospace Engineering**. Dr. Ladeinde's 2010 paper on scramjet computer simulation won **AIAA Best Paper Award**. Dr. Ladeinde was a **Visiting Scholar** at **Tsinghua University** in Beijing, China, during the summer of 2012, and has been a **Weekly Columnist** on Information and Communication Technology for an international newspaper since 2011. Dr. Ladeinde is currently the **Chair** of the **Department of Mechanical Engineering** at the State University of New York in Songdo, South Korea.

## SHORT CV

B.Sc. (First Class) Faculty of Technology, University of Ibadan, Nigeria (Formerly College of the University of London)

M.S. (Cornell University, Ithaca, New York, USA), M. Eng. Mechanical Engineering (Cornell University), Ph.D. Mechanical and Aerospace Engineering (Cornell University)

Stony Brook University (New York) **Professor** in Mechanical **Engineering for 24 Years** (1991-Present)

Over **250 Publications** in Archival Journals and Peer-Reviewed Conference Papers

**Fellow**, ASME; Associate Fellow and Life Member, AIAA; Life Member, APS; Member, SIAM

Associate **Editor**, ASCE Journal of **Aerospace Engineering**; Past Associate Editor, **AIAA Journal**;  
Weekly **Columnist** on Information and Communication Technology (**ICT**) Since 2011:  
Daily Trust Newspaper

**Journals Published in:** Physics of Fluids, Journal of Fluid Mechanics, AIAA Journal, ASME Journal of Fluids Engineering, ASME Journal of Heat Transfer, International Journal for Numerical Methods in Fluids, Journal Crystal Growth, Journal of Computational Mechanics, Journal of Scientific Computing, Journal of Applied Mathematics Modelling

**Chair**, Department of Mechanical Engineering, State University of New York (SUNY) Korea (Current)

2010 Paper on **Scramjet** Computer Simulation won **AIAA Best Paper Award**

**Chair, External Review Board**, National Aeronautics and Space Administration (**NASA**) Center for Aerospace Research at North Carolina (NC) A&T University in Greensboro, NC.

**Visiting Professor** and a Faculty **Fellow**, United States **Air Force** and the United States **National Research Council**

**Visiting Scientist**, United States **Department of Energy**, Brookhaven National Laboratory

Visiting Scholar, Tsinghua University, Beijing, China

United States Department of Defense **ITAR Certification**

(ASME=American Society of Mechanical Engineers, AIAA=American Institute of Aeronautics and Astronautics, ASCE=American Society of Civil Engineers, APS= American Physical Society, SIAM= (American) Society of Industrial and Applied Mathematics, ITAR=International Traffic in Arms Regulations)