

Experimental and Computational Non-Equilibrium Flows and Radiation V

Papers Presented at the AIAA SciTech Forum and Exposition
2024

Orlando, Florida, USA
8 – 12 January 2024

Volume 1 of 2

ISBN: 979-8-3313-0469-0

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

The contents of this work are copyrighted and additional reproduction in whole or in part are expressly prohibited without the prior written permission of the Publisher or copyright holder. The resale of the entire proceeding as received from CURRAN is permitted.

For reprint permission, please contact AIAA's Business Manager, Technical Papers. Contact by phone at 703-264-7500; fax at 703-264-7551 or by mail at 34922 Uwytkug'Xcmg{'Ftkxg.'Uwky'422, Reston, VA 20191, USA.

TABLE OF CONTENTS

VOLUME 1

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION I

Evaluation of Thermal Relaxation and Extinction of Nitric Oxide Via a Master Equation Model	1
<i>Daniil Andrienko, Iain D. Boyd, Jesse W. Streicher, Ronald K. Hanson</i>	
Recombination of Oxygen in the Vicinity of a Silica Surface	21
<i>Daniil Andrienko</i>	
Distributed Sand-Grain Roughness Effects on Blunt Body Hypersonic Transition and Heating	37
<i>Brian R. Hollis</i>	
Effect of the Internal Gas Flow Velocity on the Thermal Conductivity of Porous Thermal Protection Systems and Application to Stardust Re-Entry	60
<i>Jérémy Chevalier, Bruno Dubroca, Antonio Cosculluela, Azita Ahmadi-Senichault, Jean Lachaud</i>	

EXPERIMENTAL AND COMPUTATIONAL NON-EQUILIBRIUM FLOWS AND RADIATION I

Radiation Measurements of Shockwaves in Synthetic Air and Pure Nitrogen	79
<i>Alex B. Glenn, Peter Collen, Matthew McGilvray</i>	
Vibrational-State-Resolved Oxygen and Nitric Oxide Time-History Measurements in Shock-Heated, High-Temperature Air	111
<i>Jesse W. Streicher, Spencer C. Barnes, Ajay Krish, Ronald K. Hanson</i>	
Experimental Validation of Modeling Efforts to Estimate Nitric Oxide Emission in High Mach Number Flows	126
<i>Shubham Thirani, Irmak Taylan Karpuzcu, Deborah A Levin</i>	
Simulation-Based Guidelines for the Integration of an Emission Spectrometer into a Hypersonic Re-Entry CubeSat	135
<i>Alessio Gardi, Ellen K. Longmire, Marien Simeni Simeni</i>	

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION II

Mars Sample Return Earth Entry System Woven Roughness Mach 6 Aeroheating Test	145
<i>Jonathan Cheatwood, Christopher O. Johnston, Brian R. Hollis</i>	
Roughness Induced Heat Transfer and Shear Stress Augmentation Measurements of the HEEET Thermal Protection System	159
<i>Christopher Hambidge, David C. Steuer, Wesley J. Condren, Matthew McGilvray</i>	
Development of Two-Temperature Model in Unified Solver	180
<i>Seungyong Baeg, Raghava Davuluri, Alexandre Martin</i>	

Nanosecond CARS Measurements of Temperature and Relative CO Concentration in the Boundary Layer of a Graphite Ablator in an Inductively Coupled Plasma Torch.....	193
<i>Dan Fries, Spenser Stark, John S. Murray, Noel T. Clemens, Philip L. Varghese, Rajkumar Bhakta, Sean P. Kearney</i>	

EXPERIMENTAL AND COMPUTATIONAL NON-EQUILIBRIUM FLOWS AND RADIATION II

LASTA 2.0: Validation of a Reverse Time Integration Method.....	203
<i>Joseph Steer, Justin Clarke, Matthew McGilvray, Di Mare Luca</i>	
Study of a Reacting N ₂ /CH ₄ Plasma.....	224
<i>Cyrine Merhaben, Sean McGuire, Christophe Laux</i>	
Hegel: A High-Fidelity Flexible Software for Hypersonics and Plasma Simulations	233
<i>Alessandro Munafò, Sanjeev Kumar, Sung Min Jo, Marco Panesi</i>	
Characterizing the Effects of Radiation During Dragonfly's Titan Entry Using a Coupled Simulation Approach	254
<i>Caleb E. Thomas, Anthony Knutson, Graham V. Candler, Sung Min Jo, Marco Panesi</i>	
Characterization of Non-Equilibrium CN Via the B ² Σ ⁺ ←X ² Σ ⁺ and A ² Π←X ² Σ ⁺ Electronic Systems Using Laser Absorption Spectroscopy	266
<i>Vishnu Radhakrishna, Jennifer L. Vera, Christopher S. Goldenstein</i>	

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION III

Surface Heat Flux Prediction Using Euler Equation with Immersed Boundary Method and the Reference Temperature Method	275
<i>Shun Takahashi, Gouji Yamada, Masatoshi Kodera, Masao Takegoshi</i>	
Numerical Simulation of Transpiration Cooling on Stagnation Line in Thermochemical Non-Equilibrium.....	291
<i>Samuel Brody, Kin Sing Lau, Justin Clarke, Matthew McGilvray, Di Mare Luca</i>	
Quantification of Spalling Particles for Carbon Thermal Protection System Materials in Supersonic Air and Nitrogen Plasma	308
<i>Benjamin M. Ringel, Henry J. Boesch, Sreevishnu Oruganti, Lorenzo Capponi, Laura Villafañe Roca, Francesco Panerai</i>	
Simulation of a Low Enthalpy Ablator into a Hypersonic Boundary-Layer	320
<i>Wesley J. Condren, Tobias Hermann, Matthew McGilvray</i>	
Design, Modeling, and Implementation of Nozzle and Diffuser Geometry for an Inductively Coupled Plasma Wind Tunnel Facility for Hypersonics and Magnetoaerodynamics.....	342
<i>Tomaz J. Remec, J O. Flores Govea, Hisham Ali</i>	

EXPERIMENTAL AND COMPUTATIONAL NON-EQUILIBRIUM FLOWS AND RADIATION III

State-To-State Analysis of Recombination Processes for Non-Equilibrium N ₂ +N and O ₂ +O Systems in a 0-D Isothermal Reactor	356
<i>Aakanksha Notey, Sung Min Jo, Narendra Singh, Alessandro Munafò, Marco Panesi</i>	

Spectral Model for Nonequilibrium Radiation Induced from Flow Around a Hypersonic Body	367
<i>Joey Farmer, Andrew Oliva, Ryan McClarren, Aleksandar Jemcov, Joseph Powers</i>	
Physics-Constrained Deep Learning-Based Model for Non-Equilibrium Flows	382
<i>Edoardo Monti, Narendra Singh, Justin Sirignano, Jonathan F. MacArt, Marco Panesi, Giulio Gori</i>	
Adjoint-Based Sensitivity Analysis for Chemical Non-Equilibrium Kinetics: Application to O ₂ + O System	404
<i>Cosimo Capecchi, Sung Min Jo, Narendra Singh, Giulio Gori, Marco Panesi</i>	

HEAT PIPES, LOOP HEAT PIPES, AND TWO-PHASE DEVICES AND PROCESSES

Analytical Scheme for Modeling of Loop Heat Pipe Dynamical System Behaviors	430
<i>Triem T. Hoang</i>	
Performance Dryout Limits of Oscillating Heat Pipes: A Comprehensive Theoretical Prediction and Experimental Determination.....	442
<i>Cesar Diaz-Caraveo, Kieran Wolk, Spencer Miesner, Arturo Rodriguez, Maxwell Montemayor, Vinod Kumar, Jorge A. Muñoz, Benjamin Furst, Takuro Daimaru, Scott N. Roberts</i>	
Thermal Management of Large Area Heat Loads Using Multi-Pass Cryogenic Loop Heat Pipe	456
<i>Nathan Van Velson, Roopesh Kumar, Calin Tarau, Guillermo Fernandez-Moroni</i>	
Liquid Nitrogen Thin Film Evaporation on Stainless-Steel Micro-Pillar Arrays	469
<i>Mahadi Hasan, Manuel Valdiviez, Mohiuddin Ahmad, Ahsan Choudhuri, Md Mahamudur Rahman</i>	

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION IV

Characterization and Prediction of Surface Erosion Caused from High-Speed Micrometer Particle Impacts on Metallic Materials	477
<i>Austin Andrews, Ioannis Pothos, Nathan A. Bellefeuille, Hasan Celebi, Christopher J. Hogan, Thomas E. Schwartztruber, Bernard A. Olson</i>	
Analysis of Mars Entry Shock Wave Radiance in the T6 Stalker Hypersonic Wind Tunnel.....	486
<i>Tristan J. Crumpton</i>	
Validation of a Charring Ablator Material Response Code Against Oxyacetylene Torch Experiments on PICA Samples.....	528
<i>Christopher T. Quinn, Daniel N. Pickard, Colin M. Yee, Samantha Bernstein, Joseph H. Koo, Raul Radovitzky</i>	
High-Enthalpy Testing of Thermal Protection Materials in the Plasmatron X for Titan Atmospheric Entry	544
<i>Sreevishnu Oruganti, Lorenzo Capponi, Benjamin M. Ringel, Trey Oldham, Marco Panesi, Gregory Elliott, Francesco Panerai, Nagi N. Mansour</i>	
Statistical Variance in Radiative Properties of Porous Materials.....	557
<i>Ayan Banerjee, Luis Chacon, Yejajul Hakim, Ahmed H. Yassin, Michael Renfro, Savio J. Poovathingal</i>	

Predicting Carbon Monoxide in a Hypersonic Boundary Layer Using Finite-Rate Surface Ablation Models.....	573
<i>Erin Mussoni, Ross Wagnild, Joshua Hargis, Bryan Morreale, Jean-Pierre Delplanque</i>	

GAS PROCESSING SYSTEMS, TRANSPORT PHENOMENA AND THERMOPHYSICAL PROPERTIES

Altitude Concomitant Sampling for Venus Mass Spectrometer	589
<i>Alvin Yew, Charles Malespin, James Garvin</i>	
Semi-Analytical Model of Radiative Heat Transfer and Chemical Reactions in a Boundary Layer.....	596
<i>Samita Rimal, Kevin Pope, Greg F. Naterer, Kelly Hawboldt</i>	
Numerical Simulations of Carbon Contaminants in T6 Shock Tube Tests.....	607
<i>Justin Clarke, Alex B. Glenn, Matthew McGilvray, Di Mare Luca</i>	
Predictive Data-Driven Models of Thermophysical Properties Using Gaussian Process Regression	629
<i>Mingshuo Zhou, Chenxu Ni, Xingjian Wang</i>	
Development of the Thermal Interface Between the Dragonfly Mass Spectrometer and the DrACO Sample Delivery Carousel.....	645
<i>Peter W. Barfknecht, Kelly A. Burch, Steven T. Cale, Brian J. Comber, Matthew B. Francom, Margaret L. Hudson, Bryan L. James, Vivek A. Laljani, Hak Seung Lee, Ryan McClelland, Richard S. Ottens, Franklin L. Robinson, Paul E. Rueger</i>	

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION V

On Characterization of Flow Disturbances in Arc-Jet Testing	656
<i>Tahir Gokcen</i>	
A Comparative Study of Experimental and Simulation Data for Micrometer Particle Acceleration in a Low-Pressure Supersonic Jet Impingement System	674
<i>Austin Andrews, Nathan A. Bellefeuille, Ioannis Pothos, Hasan Celebi, Christopher J. Hogan, Thomas E. Schwartzentruber, Bernard A. Olson, Kaleb Siekmeier</i>	

VOLUME 2

Reduced Order Models of Hypersonic Aerodynamics for Aerothermal Heating Analysis.....	683
<i>David S. Ching, Patrick J. Blonigan, Michael C. Sands, Jonathan C. Murray</i>	
Modified Radiative Terms for Surface Energy Balance in Material Response Solvers.....	702
<i>Ahmed H. Yassin, Savio J. Poovathingal</i>	

THERMOPHYSICS SPECIAL SESSION - VARIABLE EMISSIVITY IN MATERIALS

Variable Emissivity Materials for Thermal Radiators: Introduction to Characterizing Thermo-chromic Infrared Surfaces in Space	726
<i>Isaac J. Foster</i>	
Variable Emissivity Thermal Radiators: Methods and Models for Characterizing Thermo-chromic Infrared Surfaces	753
<i>Michael T. Barako, Austin Howes, Vesna Radisic, Heungsoo Kim, Kwok Cheung, Valerie Lawdensky, Jonathan Allison</i>	

Thermal Characterization of Bolted Interfaces for Variable Emissivity Materials	766
<i>Trevor Bird</i>	

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION VI

Ares: A Coupling Methodology for Ablation Modeling.....	794
<i>Olivia Schroeder, Joseph Brock, Joseph C. Schulz, Georgios Bellas-Chatzigeorgis, Prakash Shrestha, Grant Palmer, Eric Stern, Graham V. Candler</i>	
An Orthotropic Thermal Conductivity Measurement in Flexible, Fibrous Insulation Materials.....	825
<i>James Davis A. Senig, John F. Maddox</i>	
Simulation of Porous Carbon Preform Ablation in a Chemically Reacting Environment.....	836
<i>Aleksander L. Zibitsker, Joel A. McQuaid, Rui Fu, Christoph Brehm, Alexandre Martin</i>	
Analysis of Arc-Jet Sample Spallation Products	852
<i>Kristen J. Price, Sean Bailey, Alexandre Martin</i>	

EXPERIMENTAL AND COMPUTATIONAL NON-EQUILIBRIUM FLOWS AND RADIATION V

Characterization of Hypersonic Instabilities Over a Double Cone.....	869
<i>Ozgur Tumuklu, Kyle M. Hanquist</i>	
State-Specific Kinetic Modeling for Predictions of Radiative Heating in H ₂ /He Entry Flows.....	884
<i>Alex T. Carroll, Guillaume Blanquart, Aaron M. Brandis, Brett A. Cruden</i>	
Maximum Entropy Based Closure for a Coarse-Grained Model of Strong Translational Non-Equilibrium.....	908
<i>Anthony Chang, Narendra Singh, Vegnesh Jayaraman, Marco Panesi</i>	
Demonstration of UV Rotational, Vibrational Temperature and Speciation Diagnostics for the Cyano-Radical in Methane-Nitrogen Mixtures	919
<i>Devin Merrell, Efaïne Chang, Ajay Krish, Peter M. Finch, Jesse W. Streicher, Ronald K. Hanson</i>	

AEROTHERMODYNAMICS, THERMAL PROTECTION SYSTEMS AND ABLATION VII

Coupled Simulations of Shoulder Ablation of a Conceptual Aeroshell.....	927
<i>Prakash Shrestha, Olivia Schroeder, Georgios Bellas-Chatzigeorgis, Joseph C. Schulz, Grant Palmer, Christopher O. Johnston, Eric Stern</i>	
Modeling the Plasma Jet in the Plasmatron X ICP Facility.....	944
<i>Prathamesh R. Sirmalla, Alessandro Munafò, Sanjeev Kumar, Daniel J. Bodony, Marco Panesi</i>	
Self-Consistent Flow-Radiation Coupling for Hypersonic Atmospheric Entry.....	962
<i>Sung Min Jo, Alessandro Munafò, Marco Panesi</i>	
Laser-Induced Fluorescence for Temperature and Density of CN and CO in the Boundary Layer of Graphite Ablation in an Inductively-Coupled Plasma Torch Plume.....	971
<i>John S. Murray, Noel T. Clemens</i>	

Characterization of Hypersonic Flow Over Slender Bodies at Sea-Level.....	983
<i>Ares Barrios-Lobelle, Francis M. Haas, Savio J. Poovathingal, Alexandre Martin</i>	
Solar-Thermal Testing of Ablator Materials in an Atomic Oxygen Plasma.....	997
<i>Nicholas A. Anderson, Lindsay Lawless, Lam Bahn, Kimberly D. Wakefield, Ricky Tang, Brian Bentz, Jeffrey D. Engerer, Francesco Panerai</i>	

EXPERIMENTAL AND COMPUTATIONAL NON-EQUILIBRIUM FLOWS AND RADIATION IV

Impact of Trace CH ₄ on Shock Layer Radiation in Outer Planet Entry.....	1014
<i>Brett A. Cruden, Augustin C. Tibère-Inglesse</i>	
Numerical Study of the Effects of Thermo-Chemical Non-Equilibrium and Surface Catalysis on Two Hypersonic re-Entry Bodies	1025
<i>Jason B. Dsouza, Neil Castelino, Valerio Viti, Henry H. Vu, Song Gao</i>	
Simulations of Non-Equilibrium Air Chemistry Compared to Hypersonic Wind Tunnel Experiments.....	1039
<i>Thomas Gross, Erik Torres, Thomas E. Schwartzenruber, Peter M. Finch, Julian Girard, Tal Schwartz, Zev Granowitz, Christopher L. Strand, Ronald K. Hanson, Wesley M. Yu, Joanna M. Austin, Hans Hornung</i>	
Near-Infrared Measurements of Cyano Radical Number Density and Temperature Using Rapidly Scanned Tunable Diode Laser Spectroscopy.....	1058
<i>Efaine Chang, Devin Merrell, Jesse W. Streicher, Ronald K. Hanson</i>	

THERMAL MANAGEMENT & CONTROL IN AIRCRAFT AND SPACECRAFT: DEVICES & APPLICATIONS INCLUDING AI AND ML

Two-Phase Refrigerant R-134a Void Fraction and Quality Correlation Study	1065
<i>Zachary J. Carner, Mitch Wolff, Abdeel Roman</i>	
Validation of a Thermal Management Concept for the Avionics Compartment of a Stratosphere HALE	1078
<i>Patrick Weber</i>	
Evaluation of Various Energy Storage Options for the Internal Thermal Loads of a Non-Airbreathing Hypersonic Vehicle	1090
<i>Logan H. Edwards, John C. Arbolino, Michael R. von Spakovsky, Pradeep Raj</i>	
Experimental Evaluation of Innovative Thermal Energy Storage Options for a Non-Airbreathing Hypersonic Vehicle's Internal Loads	1107
<i>John C. Arbolino, Logan H. Edwards, Michael R. von Spakovsky, Pradeep Raj</i>	
An EHD Gas Pump for Cooling Electronic Components in a Horizontal Channel.....	1119
<i>Shun-Feng Cheng, Jik-Chang Leong, S. C. Lin, Feng C. Lai</i>	

MICROSCALE AND MICROGRAVITY AND OTHER TOPICS

Advanced Optical Temperature Measurement of CO ₂ Flows Inside a Micro-Channel	1133
<i>Ritesh Ghorpade, Gihun Kim, Soroush Niazi, Pranzal Ahmed, Yoav Peles, Subith Vasu</i>	

Evaporation of Deformable Droplets Under Natural Convection: Comparison of DNS Results with Experiments.....	1141
<i>Meha Setiya, John A. Palmore, Yuhao Xu</i>	
Physics-Constrained Deep Learning of Incompressible Cavity Flows.....	1156
<i>Christopher McDevitt, Eric Fowler, Subrata Roy</i>	
Frequency Domain Thermal Analysis of Future Spacecraft and Systems.....	1186
<i>George M. Harpole, Jonathan W. Arenberg, Michael B. Petach</i>	

THEORETICAL, EXPERIMENTAL, AND COMPUTATIONAL HEAT TRANSFER I

Thermal Resistance from the Centerline to the Perimeter of a Cylinder.....	1204
<i>Matthew E. Taliaferro</i>	
Investigation of Slug Calorimeter Heat Flux Measurements in the Plasmatron X Wind Tunnel.....	1212
<i>Massimo Franco, Lorenzo Capponi, Sreevishnu Oruganti, Gregory Elliott, Francesco Panerai</i>	
Modeling and Analysis of an SMA Torsional Tube for Thermal Management Systems.....	1240
<i>Paula Sanjuan Espejo, Mark A. Ricklick, Isabel Melendez, Sandra Boetcher</i>	
Rarefied Flow Simulations of the Heat Transfer Across Evacuated Cryogenic Tank Insulation Structures.....	1255
<i>Martin Konopka, Eric Winkert, Christian Wendt</i>	
Non-Linear Estimators for Hypersonic Heat Flux Reconstruction.....	1272
<i>Nhat Nguyen, Luca Massa</i>	

THEORETICAL, EXPERIMENTAL, AND COMPUTATIONAL HEAT TRANSFER II

Modeling Internal Launch Vehicle Fluid Flow and Thermodynamics, Part 1: Thermodynamic Tank Network Solver.....	1315
<i>Matthew E. Taliaferro, Samuel R. Darr</i>	
Characterization of a sCO ₂ Heat Exchanger Flow Loop.....	1331
<i>David Velasco, Joseph S. Sauerbrun, Nicholas C. Lopes, Yang Chao, Sandra Boetcher, Mark A. Ricklick</i>	
Simulating Wing Thermal Loads at Supersonic Speeds.....	1345
<i>David J. Cerantola, Dan Handford, Pradeep Dass</i>	

Author Index