

Thermophysics

Papers Presented at the AIAA SciTech Forum and Exposition
2022

San Diego, California, USA and Online
3-7 January 2022

Volume 1 of 2

ISBN: 978-1-7138-5422-7

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 I

Mars Entry Instrumentation Flight Data and Mars 2020 Entry Environments	1
<i>Todd R. White, Milad Mahzari, Ruth A. Miller, Chun Y. Tang, Chris D. Karlgaard, Hannah Alpert, Henry S. Wright, Chris Kuhl</i>	
Sensitivity Study of Dust-Induced Surface Erosion During Martian Planetary Entry	18
<i>Michael D. Kroells, Amal Sahai, Thomas E. Schwartzentruber</i>	
Kinetic Monte Carlo Simulations of Nitrogen-Carbon Gas-Surface Reaction at High Temperatures	35
<i>Simon Schmitt, Alexandre Martin</i>	
High Temperature Oxidation of Graphite Under Non-Thermal Oxygen Plasma	47
<i>Nicholas A. Anderson, Souvik Bhattacharya, Kaan K. Kirmanoglu, Kelly A. Stephani, Gregory Elliott, R. M. Sankaran, Francesco Panerai</i>	

TRANSPORT AND THERMOPHYSICAL PROPERTIES

Influence of Impurities and Degradation on Carbon Fiber and Amorphous Carbon Thermal Conductivity	59
<i>Matthew Konnik, Francesco Panerai, Kelly A. Stephani</i>	
Two-Color Rotational Temperature Diagnostic for Nitric Oxide Using Ultraviolet Laser Absorption	71
<i>Ajay Krish, Jesse W. Streicher, Efaine Chang, Ronald K. Hanson</i>	
Shock Tube Radiation Measurement in Expanding Air Flows	86
<i>Augustin C. Tibere-Inglesse, Khalil Bensassi, Aaron M. Brandis, Brett A. Cruden</i>	

NON-EQUILIBRIUM FLOWS I

Nitric Oxide Vibrational Relaxation and Decomposition Rate Measurements in Shock-Heated NO-Ar and NO-N ₂ Mixtures	105
<i>Jesse W. Streicher, Ajay Krish, Efaine Chang, Ronald K. Hanson</i>	
Rovibrational-Specific Master Equation Analysis of High-Temperature Air Mixture.....	123
<i>Sung Min Jo, Alessandro Munafo, Maitreyee Sharma Priyadarshini, Simone Venturi, Marco Panesi</i>	
Investigation of Thermochemical Non-Equilibrium Models in Hypersonic Flows Using Output-Based Mesh Adaptation.....	138
<i>Kevin M. Sabo, Benjamin L. Couchman, Wesley L. Harris, David L. Darmofal</i>	
Convective Heat Transfer in Hypersonic Non-Equilibrium Reactive Flows Over the Fire II Reentry Capsule	163
<i>Farney C. Moreira, William Wolf, João Luiz F. Azevedo</i>	

MARS 2020 EDL PERFORMANCE AND INSTRUMENTATION: AEROTHERMAL AND TPS

MEDLI2 Material Response Model Development and Validation	181
<i>Joshua Monk, Jay D. Feldman, Milad Mahzari, Jose A. Santos, Todd R. White, Dinesh K. Prabhu, Hannah Alpert</i>	
Inverse Estimation of Mars 2020 Entry Aeroheating Environments Using MEDLI2 Flight Data	194
<i>Hannah Alpert, Milad Mahzari, David Saunders, Joshua Monk, Todd R. White</i>	
MEDLI2: MISP Measured Aftbody Aerothermal Environments.....	209
<i>Ruth A. Miller, Chun Y. Tang, Todd R. White, Brett A. Cruden</i>	
MEDLI2: MISP Inferred Aerothermal Environment and Flow Transition Assessment	228
<i>Chun Y. Tang, Milad Mahzari, Dinesh K. Prabhu, Hannah Alpert, Brett A. Cruden</i>	
Mars 2020 Reconstructed Aerothermal Environments and Design Margins.....	237
<i>Karl T. Edquist, Milad Mahzari, Hannah Alpert</i>	

SAMPLE ACQUISITION AND GAS PROCESSING SYSTEMS FOR SPACE EXPLORATION I

Understanding Sampling Hardware Cleanliness from Perseverance Lessons Learned, and Forward Approach to Biosignature Missions	263
<i>Anthony T. Wong, William A. Hoey, Maxwell Martin, Carlos Soares, Kenneth Hurst, Eric Roberts, Rebecca Perkins, Paul Boeder, John Alred, Thora Maltais, Lori Shiraishi</i>	

AEROTHERMODYNAMICS II

Simulating Oxidation of Carbon Surfaces by Atomic Oxygen Coupled with a Finite Rate Oxidation Model	275
<i>Kaan K. Kirmanoglu, Nicholas A. Anderson, Francesco Panerai, Kelly A. Stephani, Joseph C. Ferguson, Sigrid Close</i>	

THEORETICAL, EXPERIMENTAL, AND COMPUTATIONAL HEAT TRANSFER

Impact of Fluid Property Modeling on Heat Transfer Deterioration	288
<i>Nelson P. Longmire, Daniel T. Banuti</i>	
Thermal Performance of a Ceramic Heater Ignition Device for Aircraft Propulsion Applications.....	299
<i>Austen Motily, Richard Alonso, Kenneth S. Kim, Chol-Bum Kweon, Tonghun Lee</i>	
Effect of Molecular Oxygen Dissociation on Nitric Oxide Ultraviolet Radiation.....	317
<i>Irmak Taylan Karpuzcu, Matthew P. Jouffray, Deborah A. Levin</i>	

NON-EQUILIBRIUM FLOWS II

Direct Molecular Simulation of Rovibrational Relaxation and Chemical Reactions in Air Mixtures.....	347
<i>Erik Torres, Eric C. Geisfeld, Thomas E. Schwartzenruber</i>	
A Multi-Physics Modeling Framework for Inductively Coupled Plasma Wind Tunnels.....	374
<i>Alessandro Munafò, Robert Chiodi, Sanjeev Kumar, Vincent Le Maout, Kelly A. Stephani, Francesco Panerai, Daniel J. Bodony, Marco Panesi</i>	

Investigation of the Breakdown of Navier-Stokes Equation Using Objective Molecular Dynamics 395
Gunjan Pahlani, Thomas E. Schwartzentruber, Richard James

Importance of Exchange Processes in Earth and Mars Atmospheric Kinetics: Application to HCN System 407
Maitreyee Sharma Priyadarshini, Simone Venturi, Richard L. Jaffe, David W. Schwenke, Marco Panesi

AEROTHERMODYNAMICS III

Simulation of Dust-Laden Flows in the DLR L2K Facility 423
Grant E. Palmer, Amal Sahai

A Semi-Classical Phonon-induced Desorption Model for Carbon Surfaces 437
Chaithanya Kondur, Kelly A. Stephani

THERMAL PROTECTION SYSTEMS/ABLATION I

Thermo-Chemical-Structural Modeling of Carbon Fiber Pitting and Failure Mechanism 452
Rui Fu, Simon Schmitt, Alexandre Martin

Numerical Investigation on the Effect of Spectral Radiative Heat Transfer Within an Ablative Material 467
Raghava Davuluri, Rui Fu, Kaveh A. Tagavi, Alexandre Martin

Extension of Kinetic Monte Carlo Simulation Framework to Multilayer Graphene and Graphite Oxidation 477
Simon Schmitt, Rui Fu, Alexandre Martin

THERMAL PROTECTION SYSTEMS/ABLATION II

Numerical Investigation of an Oxyacetylene Torch with Regards to an Ablative Material Used in Re-Entry 486
Luke Fortner, John F. Maddox, Alexandre Martin

Heat Transfer Study of a Conically Shaped Hypersonic Vehicle in Glide 512
Nathan R. Thomas, Akhil Marayikkottu Vijayan, Deborah A. Levin

CHyPS: a High-Order Material Response Solver for Ablative Thermal Protection Systems 531
Robert M. Chiodi, Kelly A. Stephani, Marco Panesi, Daniel J. Bodony

Experimental Assessment of Thermal Response of Insulating Thermal Protection Systems with Designed-In Features 546
Nathaniel Skolnik, Zachary R. Putnam

NON-EQUILIBRIUM FLOWS III

Quasi Classical Trajectory Analysis of Oxygen Recombination Using a Consistent Binary Lifetime Framework 579
Eric C. Geistfeld, Erik Torres, Thomas E. Schwartzentruber

Sensitivity Analysis of Gas-Surface Modeling in Nonequilibrium Flows 597
Jacob T. Needels, Umran Duzel, Kyle M. Hanquist, Juan J. Alonso

Kinetics of the Electronic States of Molecular Nitrogen in a Recombining Air/Argon Plasma.....	612
<i>Ulysse Dubuet, Pierre Mariotto, Christophe O. Laux, Marie-Yvonne Perrin</i>	
Advancements in the Modeling and Simulation of Shock Tube Flows.....	620
<i>Matthew Satchell, Justin Clarke, Peter L. Collen, Matthew McGilvray, Luca Di Mare</i>	
Towards Efficient Simulations of Non-Equilibrium Chemistry in Hypersonic Flows: A Physics-Informed Neural Network Framework.....	633
<i>Ivan Zanardi, Simone Venturi, Marco Panesi</i>	

THERMAL PROTECTION SYSTEMS/ABLATION III

Estimating Effective Radiative Properties and In-Depth Radiative Heating of Porous Ablators	647
<i>Ayan Banerjee, Alexandre Martin, Savio J. Poovathingal</i>	

VOLUME 2

In-Depth Chemistry Model for High Temperature Oxidation of Carbon-based Thermal Protection System Materials	666
<i>Victoria Arias, Harley Johnson, Kelly A. Stephani</i>	
Mesh Deformation Boundary Conditions for Three-Dimensional Ablation Solvers	675
<i>Adam J. Amar, Justin M. Cooper, A. Brandon Oliver, Giovanni Salazar, Lucas Agricola</i>	
Mechanical Response of Isotropic Graphite Due to Oxidation Induced Degradation	702
<i>Henry X. Varona, Jacob Faibussowitsch, Kelly A. Stephani, Harley Johnson, Gregory Elliott, Jonathan Freund, Francesco Panerai</i>	
Effect of Blowing Mass Flux on Porous Mesostructure Surface Properties for Hypersonic Ablation.....	718
<i>Sahadeo Ramjatan, Michael D. Kroells, Thomas E. Schwartzentruber</i>	

RADIATION I

High-Temperature Infrared-Based Diagnostic for Nitric Oxide Using Tunable Diode Laser Absorption Spectroscopy.....	733
<i>Efaine Chang, Jesse W. Streicher, Ajay Krish</i>	
Infrared Emission Measurements of a Recombining CO ₂ Plasma	745
<i>Corentin Grimaldi, Sean McGuire, Christophe O. Laux</i>	
Mid-Wave Infrared Radiation Experiments in Hypervelocity CO ₂ Blunt Body Flow	755
<i>Matthew G. Leibowitz, Joanna M. Austin</i>	
Characterization of a Plasma Jet Flow Using Emission Spectroscopy and Laser-Induced Breakdown Velocimetry.....	774
<i>Killian E. Samuels, Aleksander Clark, Walker McCord, Seth Holladay, Zhili Zhang, Damiano Baccarella</i>	

AEROTHERMODYNAMICS IV

Pre- and Post-Flight Hypersonic Glide Vehicle Surface Roughness Measurements.....	784
<i>Cassandra J. Butler, Elizabeth K. Benitez, Joseph S. Jewell, Christopher J. Ruscher, Sivaram P. Gogineni</i>	

Molecular Recombination Dynamics of Nitrogen from Quasi-Classical Trajectory Simulations of the N₃ System 796
Chaithanya Kondur, Kelly A. Stephani

Numerical Investigation of Film Coefficient Engineering Methodology for Dissociated, Chemically Reacting Boundary Layers 810
Justin M. Cooper, Giovanni Salazar, Alexandre Martin

Material Response Modeling of MMOD Cavities..... 835
Olivia M. Schroeder, Prakash Shrestha, Grant Palmer, Eric Stern, Graham V. Candler

THERMAL MANAGEMENT AND CONTROL IN AIRCRAFT AND SPACECRAFT

Architectures to Reduce Heater Power for Large Space Telescopes..... 849
Erika T. Bannon, Kevin Weed, J. Scott Knight, Laura Coyle, Sarah Grunsfeld

Thermal Analysis of an ESPA Class Host Satellite Using Oscillating Heat Pipes and Deployable Solar Array Backed Radiator..... 859
Alexander Deravanessian, Kevin R. Anderson

A Portable High-Density Power Technology for Space, Lunar, and Planetary Applications..... 888
Sang H. Choi, Dennis M. Bushnell, Robert W. Moses

An Experimental Study on Ice Accretion and Anti-/De-Icing of a Pitot Tube 898
Haiyang Hu, Faisal Al-Masri, Hui Hu

NON-EQUILIBRIUM FLOWS AND RADIATION

Numerical Study on Mitigation of Reentry Blackout by Effects of Air-Film 916
Takashi Miyashita, Hideto Takasawa, Yusuke Takahashi, Nobuyuki Oshima, Lars Steffens, Burkard Esser, Ali Guelhan

Hayabusa2 Capsule Reentry: Australian Airborne Observation Emission Spectroscopy Calibration and Preliminary Analysis 927
Byrenn Birch, Fabian Zander, David R. Buttsworth, Lachlan Noller, Allan Payne

Improving PIC-DSMC Simulations of Electrical Breakdown Via Event Splitting 941
Georgii Oblapenko, David B. Goldstein, Philip Varghese, Christopher Moore

System Design and Preliminary Analysis of the UQ Near Infrared Spectroscopy Data of the Hayabusa2 Re-Entry..... 955
Christopher M. James, Matthew Thompson, Steve F. Apirana, Fabian Zander, David R. Buttsworth, Allan Payne

Experimental Non-Equilibrium Radiation Measurements for Low-Earth Orbit Return..... 971
Alex B. Glenn, Peter L. Collen, Matthew McGilvray

THERMAL PROTECTION SYSTEMS/ABLATION IV

Hypersonic Foldable Aeroshell for THERmal Protection Using ORigami (HATHOR): Aerothermal Analysis 1006
Michela Gramola, Paul J. Bruce, Matthew J. Santer

RADIATION II

Shock-Layer Radiation Insights Available Through Flowfield-Property Binning	1028
<i>Christopher O. Johnston</i>	
Measurements and Modeling of High Temperature Air Emission	1045
<i>Sean McGuire, Carolyn Jacobs, Pierre Mariotto, Corentin Grimaldi, Christophe O. Laux</i>	
High-Speed Interband Cascade Laser Absorption Sensor for Multiple Temperatures in CO ₂ Rovibrational Non-equilibrium	1062
<i>Christopher Jelloian, Nicolas Q. Minesi, Raymond M. Spearrin</i>	

HEAT TRANSFER AND FLUID FLOW

Ab Initio Simulation of a Dissociating Nitrogen Flow Over a Wedge	1070
<i>Maninder S. Grover, Paolo Valentini, Nicholas J. Bisek, Ashley M. Verhoff</i>	
Predictive and Efficiency Parameters for Non-Vented Cryogenic Propellant Fill	1088
<i>Jason W. Hartwig, Justin Clark</i>	
Viscosity of Nitrogen from Ab Initio Direct Molecular Simulations	1098
<i>Paolo Valentini, Maninder S. Grover, Nicholas J. Bisek, Ashley M. Verhoff</i>	
Spectral Element Method Based Conjugate Heat Transfer Simulation of Impinging Jet Flows	1107
<i>Nadish Saini, Muhsin Ameen, Saumil Patel, Miad Yazdani</i>	
Computational Study on Coaxial Nitrogen-Hydrogen Injection at Supercritical Conditions	1121
<i>Leandro B. Magalhães, Andre R. Silva, Jorge M. Barata</i>	

HEAT TRANSFER, TPS, AND NON-EQUILIBRIUM FLOW

Experimental Simulation of Gas Giant Entry in the PWK1 Arcjet Facility Including CH ₄	1133
<i>Stefan Loehle, Arne Meindl, Erik Poloni, Joseph Steer, Tamara Sopek, Matthew McGilvray, Louis Walpot</i>	
Meteorite Ablation and High-Speed Emission Spectra in Plasma Wind Tunnel	1141
<i>Ranjith Ravichandran, Stefan Loehle</i>	
Use of Supercritical CO ₂ Impingement Cooling for a Hypersonic Leading Edge	1151
<i>Manoj Prabakar Sargunraj, Marcel Otto, Ladislav Vesely, Erik Fernandez, Jayanta S. Kapat, Valerio Viti</i>	
Analysis of Shock Deceleration Effects on Radiation Experiments in the NASA Electric Arc Shock Tube	1165
<i>Peter L. Collen, Matthew Satchell, Luca Di Mare, Matthew McGilvray</i>	
Conjugate Heat Conduction Analysis of Mach 6 Flow Over a Blunted Wedge	1181
<i>Jesse Craig, Mathew Ruda, Luca Massa</i>	

HEAT TRANSFER AND FLUID FLOW II

Improved Heat Transfer Prediction for High-Speed Flows Over Blunt Bodies Using Adaptive Mixed-Element Unstructured Grids	1217
<i>Gabriel Nastac, Robert W. Tramel, Eric J. Nielsen</i>	
The Dirty Secrets of Planetary Exploration: Lessons from Interactions with Regolith.....	1243
<i>Ralph D. Lorenz</i>	
Thermal Sort: A Simple Optimization Problem in Avionics Cooling	1255
<i>Ambady Suresh</i>	

OTHER TOPICS IN THERMOPHYSICS

Adapting a Multi-Material ALE with AMR Method for Physics of High-Speed Material Interactions	1262
<i>Peter Yip, Erik Torres, Ioannis Nompelis, Thomas E. Schwartzentruber, Aaron Fisher, David C. Eder, Alice Koniges</i>	
Fully-Coupled Simulation of Low Temperature Ablator and Hypersonic Flow Solver.....	1276
<i>Aleksander L. Zibitsker, Joel McQuaid, Christoph Brehm, Alexandre Martin</i>	
Development and Verification of a Mesh Deformation Scheme for a Three Dimensional Ablative Material Solver	1303
<i>Aleksander L. Zibitsker, Joel McQuaid, Christoph Brehm, Alexandre Martin</i>	
Interaction of Transpiration Cooling with a Stagnating Crossflow	1318
<i>Nicholas W. Rathay, Gustavo Ledezma, Thomas Dyson</i>	

Author Index