

*The 6<sup>th</sup> European Symposium on*

# **Aerothermodynamics for Space Vehicles**

3–6 November 2008  
Versailles, France

*Sponsored by*

**European Space Agency (ESA)  
Centre Français de Recherche Aéronautique (ONERA)  
Centre National d'Études Spatiales (CNES)**

*Co-Sponsored by*

**Deutsches Zentrum für Luft- und Raumfahrt (DLR)  
Von Karman Institute for Fluid Dynamics (VKI)  
Centro Italiano Ricerche Aerospaziali (CIRA)**

**European Space Agency  
Agence spatiale européenne**

### Technical and Programme Committee

J.L. Verant, ONERA (F)	R. Hillier, Imperial College (UK)
J. Délery, ONERA (F)	O. Chazot, VKI (B)
J. Oswald, CNES (F)	H. Deconinck, VKI (B)
H. Lambare, CNES (F)	M. Ivanov, ITAM (RU)
F. Cahuzac, CNES (F)	J.C. Lengrand, CNRS (F)
B. Chemoul, CNES (F)	P. James, SNECMA (F)
S. Guédron, CNES (F)	J.P. Tribot, Dassault Aviation (F)
H. Speckmann, DLR (D)	H. Olivier, RWTH Aachen (D)
J. Longo, DLR (D)	R. Radespiel, TU-Braunschweig (D)
K. Hannemann, DLR (D)	M. Onofri, Univ. of Rome (I)
H. Hald, DLR (D)	R. Brun, Univ. of Provence (F)
A. Gülhan, DLR (D)	G. Herdrich, IRS (D)
E. Bregman, EADS (D)	F. Scarano, TU Delft (NL)
G. Hagemann, EADS (D)	P. Erbland, AFRL (USA)
P. Tran, EADS (F)	D. Knight, Rutgers Univ. (USA)
S. Radulovic, EADS (F)	E. Venkatapathy, NASA Ames (USA)
S. Borrelli, CIRA (I)	R. Boyce, Univ. of Queensland (AUS)
A. Schettino, CIRA (I)	G. Tumino, ESA/HQ (F)
M. Marini, CIRA (I)	R. Molina, ESA/ESTEC (NL)
E. D'Aversa, ASI (I)	W. Kordulla, ESA/ESTEC (NL)
L. Biagioni, ALTA (I)	L. Marraffa, ESA/ESTEC (NL)
C. Chiarelli, TAS (I)	J. Steelant, ESA/ESTEC (NL)

### Organising Committee

G. Saccoccia	ESA/ESTEC (Chairman)
P. Reijasse	ONERA (Co-chair)
B. Chanetz	ONERA (Co-chair)
J. Muylaert	ESA/ESTEC (Co-chair)
F. Cheuret	ESA/ESTEC (Co-chair)
G. Elfering	ESA Conference Bureau
D. Devezaux	ONERA International Affairs
M. Coët	ONERA

<i>Publication</i>	Proc. of 'The 6th European Symposium on Aerothermodynamics for Space Vehicles', 3-6 November 2008, Versailles, France (ESA SP-659, January 2009)
<i>Edited by</i>	H. Lacoste & L. Ouwehand
<i>Published and distributed by</i>	ESA Communication Production Office ESTEC, Noordwijk, The Netherlands
<i>Price</i>	€ 60
<i>ISBN</i>	978-92-9221-223-0
<i>ISSN</i>	1609-042X
<i>Copyright</i>	© 2009 European Space Agency

# Contents

## Session 1: EXPERT 1

European Experimental Re-Entry Testbed EXPERT: Qualification of Payloads for Flight  
*F. Ratti, J. Gavira, A. C. Thirkettle et al.*

Testing of EXPERT Nose Material and Sensor Heads in the DLR ARCJET Facilities  
*K. Stubicar, T. Reimer, G. Koppenwallner et al.*

EXPERT Open Flap Instrumentation and its Ground Qualification  
*A. Gülhan, T. Thiele, F. Siebe & J. Häberle*

Numerical Analysis of the EXPERT Open Flap Assembly in Plasma Wind Tunnel Conditions  
*M. Di Clemente, M. Marini & S. Di Benedetto*

## Session 2: Radiation Modeling and Validation

Progress on the Computation of Radiation-Flowfield Coupled Solutions  
*J. A. Merrifield & M. Fertig*

Radiative Gas Dynamics: The Spherical Harmonics Method to Solve the Radiative Transfer Equation  
*G. Lenguito & S. Borrelli*

Assessment on the Interaction of Radiation, Convective Heating, and Ablation for the "RadFlight" Re-Entry Flight Experiment  
*J.J. Na, C. Park, K.S. Chang & J. Muylaert*

## Session 3: Airbreathing Propulsion I: LAPCAT and ATLLAS

Key Technologies for Hypersonic Sustained Flight Assessed within LAPCAT and ATLLAS Projects  
*J. Steelant*

Conceptual Design of a Mach 8 Hypersonic Cruiser with Dorsal Engine  
*N. Murray, J. Steelant & A. Mack*

Design and Experimental Verification of a Scram-Jet Inlet in Frame of ESA's LAPCAT Program  
*A. Henckels, P. Gruhn & A. Gülhan*

CFD Investigation of Scaling Laws for Hydrogen Fuelled Scramjet Combustors  
*S. Karl, K. Hannemann & J. Steelant*

## **Session 4: Launchers/Solid Propulsion**

Numerical Simulation of Multiphase Flow in Solid Rocket Motors  
*A. Attili, B. Favini, M. Di Giacinto & F. Serraglia*

## **Session 5: EXPERT II**

Inverse Temperature Mapping of Re-Entry Vehicle Control Surfaces Using Infrared Thermography  
*C. Pereira, B. Hirtz, A. Vuilleumier et al.*

Expert Hypersonic Roughness Induced Transition Experiment  
*S. C. Tirtey, J. Thoemel & O. Chazot*

Ground Test Investigation on a Thermal Protection System Junction  
*F. Panerai, J. Thoemel & O. Chazot*

A Semi-Empirical Model for Oxygen Recombination on PM1000 Surface  
*S. Di Benedetto & C. Bruno*

Air Catalycity Determination in Plasma Wind Tunnels and Diffusion Reactors  
*O. Chazot, J. Thoemel & M. Balat-Pichelin*

## **Session 6: CFD and Algorithms**

On the Influence of Finite Rate Chemistry in LES of Self-Ignition in Vitiated Hot Confined Supersonic Air Flow  
*M. Berglund, E. Fedina, C. Fureby et al.*

On Potential Flow Solutions from the Division Algebras  
*G. C. Dijkhuis*

A Node-Pair BGK Kinetic Scheme for Flows at Moderate Knudsen Numbers  
*M. Fossati & L. Vigevano*

Numerical Simulation of a Reactive Flow in an Overexpanded Nozzle  
*B. Sainte-Rose, N. Bertier & F. Dupoirieux*

Large-Eddy Simulation of the Base Flow of a Cylindrical Space Vehicle Configuration  
*J.-H. Meiß & W. Schröder*

## **Session 7: Airbreathing Propulsion II: LAPCAT and ATLLAS**

Experimental Investigation of Different Scramjet Hydrogen Injection Systems  
*K. Hannemann, J. Martinez Schramm, S. Karl & J. Steelant*

Simulation-Based Stochastic Sensitivity Analysis of a Mach 4.5 Mixed-Compression Intake Performance  
*H. Kato & K. Ito*

Visual Characterisation of Hydrocarbon Jets at Sub- and Supercritical Conditions  
*I. Stotz, G. Lamanna, B. Weigand & J. Steelant*

Experimental Characterization of Turbulence Spots on a Flat Plate at Mach 6  
*A. Passaro, D. Baccarella, P. Caredda et al.*

## **Session 8: Shock Waves Interaction**

Comparative Study of Stagnation Point Anomalies by Means of Shock Capturing and Shock Fitting Unstructured Codes  
*A. Bonfiglioli & R. Paciorri*

Numerical Simulation of Shock-Shock Interactions with an Unstructured Shock-Fitting Technique  
*R. Paciorri & A. Bonfiglioli*

Extrapolation-to-Flight of Aerodynamic Heating Measurements and Determination of In-Flight Radiation-Equilibrium Surface Temperature in Hypersonic / High Enthalpy Flow Conditions  
*G.A. Simeonides*

Aerothermodynamic Study of a Generic Flap Configuration with Gap in HEG  
*J. Martinez Schramm, B. Reimann, A. Hoffie et al.*

Experimental Results on a Sharp Double Cone in a Mach 9 Non-Equilibrium Flow  
*P. Caredda, A. Passaro, D. Baccarella et al.*

## **Session 9: EXPERT III**

Aerodynamics of the EXPERT Re-Entry Ballistic Vehicle  
*A.M. Kharitonov, N.P. Adamov, I.I. Mazhul et al.*

Aerodynamics of the EXPERT Reentry Capsule Along the Descent Trajectory  
*P. Vashchenkov, A. Kashkovsky & M. Ivanov*

Simulation of Stagnation Point Heating and Predicting Surface Catalysity for the  
EXPERT Re-Entry Conditions

*A.F. Kolesnikov, A.N. Gordeev & S.A. Vasil'evsky*

Intermetallics for Thermal Protection Systems

*J. Marcos*

Assessment on EXPERT Descent and Landing System Aerodynamics

*H. Wong, J. Muylaert, D. Northey & D. Riley*

## **Session 10: Physics of High Speed Gas Flow I**

Modeling of Supersonic Plasma Flows in the VKI Minitorch by Means of a  
Collisional Radiative Model

*M. Panesi, A. Munafò & O. Chazot*

An Experimental Investigation of Hypersonic Transverse Jet Interactions in Laminar,  
Transitional and Turbulent Flows

*G.S. Freebairn, R.R. Boyce & N. Mudford*

Fiber Optic High Temperature Sensors for Re-Entry Vehicles

*E. Haddad, R. Kruzelecky, J. Zou et al.*

The Effect of Pressure Gradients on Surface Heat-Transfer in Hypersonic, Turbulent Flows

*N. Murray & R. Hillier*

Experimental Investigation of a Supersonic Backward Facing Step Flow

*F.F.J. Schrijer & D. Modenini*

Study of Solid Particle Behavior in High Temperature Gas Flows

*A. Majid, U. Bauder, T. Stindl et al.*

## **Session 11: Airbreathing Propulsion III**

Scramjet Research Activities at the Institute of Flight Propulsion of the  
Technische Universitaet Muenchen

*D. Maier, S. Kirstein, T. Fuhrmann et al.*

Numerical Investigation of the Performance of a Supersonic Combustion Chamber and  
Comparison with Experiments

*M.C. Banica, J. Chun, T. Scheuermann et al.*

Scramjet Combustor Characteristics at Hypervelocity Condition over Mach 10 Flight

*M. Takahashi, T. Komuro, K. Sato et al.*

Electrically Driven Supersonic Combustor

*S. Leonov & V. Sabelnikov*

## Session 12: Aero-Acoustics and Fluid Structure Coupling

### Invited Paper

Kinetics and Transport in Non-Equilibrium Flows

*R. Brun*

Acoustic Model for Supersonic Jet Interaction with a Complex Deflector

*V. V. Kudryavtsev & A. V. Safronov*

Numerical Simulation of Liquid-Structure Interaction Problems in a Tank for Aerospace Applications

*E. Bucchignani, G. Pezzella & A. Matrone*

CFD Analysis of Heat Transfer to Transcritical Fluids in Liquid Rocket Engines

*M. Pizzarelli, A. Urbano, F. Nasuti & M. Onofri*

## Session 13: IXV I

Characterization of the Aerothermal Environment of the IXV Experimental Vehicle by Means of WTT and CFD

*E. Cosson, J. Soler, V. Pierre et al.*

An Experimental Study on Aerothermal Heating of the IXV Configuration During Re-Entry

*D. Neeb, A. Gülhan, E. Cosson et al.*

Experimental and Numerical Investigation of Aerothermal Characteristics of the IXV Hypersonic Vehicle

*P. Roncioni, G. Ramuzzi, M. Marini et al.*

IXV CFD Simulations for Wind Tunnel Rebuilding and Extrapolation to Flight

*R. Von Kaenel, S. Sanchi, J.B. Vos et al.*

Numerical Assessment of Wall Catalytic Effects on the IXV Surface

*R. Paciorri, M. Onofri, D. Cardillo et al.*

Overview of the In-Flight Experimentations and Measurements on the IXV Experimental Vehicle

*E. Cosson, S. Giusto, A. Del Vecchio & S. Mancuso*

## Session 14: Physics of High Speed Gas Flow II

How Diffusion Modeling Affects Prediction of Heat Flux Loads

*P.F. Barbante*

State-to-State Kinetics in Nozzle Flows of the Reacting 5-Component Air Mixture

*E.A. Nagnibeda, S.S. Bazilevich & K.A. Sinitsyn*

The Energy Distribution Mechanisms of the Near Wakes of Planetary Entry Probes  
*S. Balage, R. Boyce, N. Mudford & S. O'Byrne*

Modelling of Radiation Heat Transfer in Reacting Hot Gas Flows  
*A. Thellmann & Ch. Mundt*

CFD Modeling of Thermally and Chemically Nonequilibrium Flows in Discharge Channel and in Subsonic Plasmatron Jets Around of the Flat-Face Model  
*V.I. Sakharov, A.F. Kolesnikov, A.N. Gordeev & J.-L. Verant*

## **Session 15: Airbreathing Propulsion IV**

Features of Ignition and Stable Combustion in Supersonic Combustor  
*M. Goldfeld, A. Starov & K. Timofeev*

Experimental Studies of Compressible Vortex Loops Interaction with an Ejector Inlet  
*H. Zare-Behtash, N. Gongora-Orozco & K. Kontis*

Effect of Injector Shape on Film Cooling in Hypersonic Flow  
*J. Beloki Perurena, K. A. Heufer & H. Olivier*

## **Session 16: Transition and Vortical Flowfield**

Instability Investigations in Non-Equilibrium Hypersonic Reacting Flat-Plate Boundary-Layer Flow with DNS  
*C. Stemmer*

Numerical Simulation of Receptivity of a Hypersonic Boundary Layer over a Surface with Temperature Jump  
*V. G. Soudakov, I. V. Egorov & A. V. Fedorov*

Numerical Simulation of Stability of a Supersonic Flow over a Wavy Wall  
*A. V. Novikov, I. V. Egorov & A. V. Fedorov*

Active Boundary Layer Trip for Supersonic Flows  
*F. Schloegel, G. Parniagua & S. Tirtey*

Analysis of the Flow Dynamics of Compressible Vortex Rings Using Compressible Gases  
*R. Mariani & K. Kontis*

## **Session 17: IXV II**

FLPP IXV Re-Entry Vehicle, Aerodynamic Characterisation  
*J.-P. Belmont, O. Cantinaud, J.-P. Tribot et al.*

FLPP IXV Re-Entry Vehicle, Hypersonic Aerodynamics Characterisation  
*Ph. Tran, M. Dormieux, J. Fontaine et al.*

FLPP IXV Re-Entry Vehicle, Supersonic Characterisation Based on DNW SST Wind Tunnel Tests and CFD  
*C. Kapteijn, H. Maseland, C. Chiarelli et al.*

FLPP IXV Re-entry Vehicle, Transonic Characterisation Based on FOI T1500 Wind Tunnel Tests and CFD  
*L. Torngren, C. Chiarelli, V. Mareschi et al.*

Theoretical-Numerical Design of a Plasma Wind Tunnel Test for a Large TPS Demonstrator  
*G.C. Rufolo, S. Di Benedetto & M. Marini*

Review of Surface Properties of Thermal Protection Materials for the Design of IXV Thermal Protection System  
*J. Thoemel, E. Cosson & O. Chazot*

Aerothermodynamic Analysis of a Scirocco Plasma Wind Tunnel Test on a Large TPS Demonstrator and Comparison with Experimental Results  
*S. Di Benedetto, G.C. Rufolo, M. Marini & E. Trifoni*

Investigation of Pre-X Reentry Vehicle Aerodynamics at TsAGI Wind Tunnels  
*A. Vaganov, S. Drozdov, V. Pliashchnik et al.*

## **Session 18: Chemistry of High Speed Gas Flow**

Chemical Non Equilibrium Model of the Martian Atmosphere  
*V. Hannemann & A. Mack*

Dust Particle Effects on TPS Qualification for Martian Atmosphere  
*B. Esser, A. Gülhan, U. Koch et al.*

Simulation of Hypersonic CO<sub>2</sub> Flows in a Range of Academic and Industrial Facilities  
*J.C. Beck & A.J. Smith*

Comparison of Non-Equilibrium Supersonic CO<sub>2</sub> Flows with Real Gas Effects near a Blunt Body  
*E.V. Kustova, E.A. Nagnibeda, Yu.D. Shevelev & N.G. Syzranova*

Numerical Investigation of Non-Equilibrium Radiation of CO<sub>2</sub>-N<sub>2</sub> Mixtures in a Shock Viscous Layer  
*A.B. Gorshkov, V.I. Vaslov, G.N. Zalogin & Yu.D. Shevelev*

Chemical Kinetics in Hypersonic Boundary Layer  
*N. Belouaggadia, I. Armenise, M. Capitelli & R. Brun*

A Reanalysis of the Zeldovich Reactions:  $O+N_2 \leftrightarrow NO+N$  and  $N+O_2 \leftrightarrow NO+O$   
*J. Daniel Kelley*

Catalytic Properties Analysis of Heat Shield Materials by Molecular Dynamic Methods  
*V.L. Kovalev & M.Ju. Pogosbekian*

## **Session 19: Combustion and Nozzle Flow**

Non-Equilibrium Effects in Shock Induced Combustion

*V.I. Kopchenov, L. V. Bezgin, N.S. Titova & A.M. Starik*

Numerical Simulation and Experimental Investigation of Mass Supply Processes in Supersonic Combustor

*M.A. Goldfeld, N.N. Fedorova, I.A. Fedorchenko & Yu.V. Zakharova*

Influence of Boundary Layer on Supersonic Cavity Flow Dynamics

*V. Togiti, M. Breuer & J. Longo*

Issues with the Application of Thermographic Phosphors to Measure High Temperatures in a Gas Turbine Engines

*A.H. Khalid & K. Kontis*

3D Unsteady Numerical Investigation of an Overexpanded Thrust Optimized Contour Nozzle

*A. Shams, P. Comte, S. Girard et al.*

Numerical Simulations of Flow Separation in Over-Expanded Supersonic Nozzle with Rectangular Cross Section

*R.O. Bura, M.H. Askary & H.J. Bagus*

Flow Structure of Supersonic Underexpanded Jet with Artificial Streamwise Vortices

*V. Zapryagaev, N. Kiselev & I. Kavun*

A Fluid Structure Coupling of the Ariane-5 During Start Phase by DES

*H. Lüdeke & J.B. Calvo*

## **Session 20: RTO-WG043 / Code Validation**

Evaluation of CFD for 2-D and 3-D High-Speed Flow Predictions

*D.V. Gaitonde*

High-Speed Unsteady Flows around Concave Axisymmetric Bodies: Flow Instabilities and their Suppression

*A. Panaras & D. Drikakis*

Numerical Investigation of Double-Cone Flows with High Enthalpy Effects

*I. Nompelis & G.V. Candler*

Analysis of the Reentry-F Experiment Using Detached Eddy Simulation

*M. Barnhardt & G.V. Candler*

Experimental Capsule Afterbody Flow Investigation

*F.F.J. Schrijer, G. Mignoli, F. Scarano & L.M.G.F.M. Walpot*

## **Session 21: High Speed Flow and Reentry Vehicles I**

SHEFEX II – Aerodynamic Re-Entry Controlled Sharp Edge Flight Experiment  
*J. M. A. Longo, J. Turner & H. Weihs*

Heat Transfer of Reentry Vehicles During Atmosphere Flight  
*D. A. Churakov, A. B. Gorshkov, R. V. Kovalev et al.*

Elevon-Elevon Gap Flow Impingement  
*J. M. A. Longo, B. Reimann, S. Strom et al.*

Aerodynamic Coefficients of Entry Vehicle Demonstrator from Free Flight Range Testing  
*C. Berner, V. Fleck, E. Sommer & P. Tran*

## **Session 22: Measurement Techniques and Instrumentation**

Mid-Infrared Diode Laser Absorption Spectroscopy Measurements in CO/CO<sub>2</sub> Hypersonic Flows of F4 and Simoun  
*A. Mohamed, J.-L. Verant, J. Soutadé et al.*

Development of an In-Flight Measurement Instrument Based on Electron Beam Fluorescence (EBF) for Shock Layer Characterisation  
*B. Diop, A. Mohamed & J. Bonnet*

Laser Induced Fluorescence and Diode Laser Absorption Spectroscopy Measurements in CO/CO<sub>2</sub> Hypersonic Flow of LBK  
*U. Koch, J. Riehmer, B. Esser & A. Gülhan*

Mathematical Interpretation of Observational Data of the Stardust SRC Re-Entry  
*M. I. Gritsevich*

The Study of Hypersonic Heat Transfer by Liquid Crystals Thermography  
*V. N. Kovrizhina, A. M. Kharitonov, A. P. Petrov et al.*

Development of Cavity Enhanced Absorption Spectroscopy for O<sub>2</sub> Measurements in Reentry Flows  
*J. Courtois, A. K. Mohamed & D. Romanini*

## **Session 23: Advanced Flow Control**

MHD Interaction in a Weakly Ionization Mach 15 Argon Flow  
*A. Passaro, D. Baccarella, P. Caredda et al.*

Numerical Modelling of the Interaction between an Electrical Discharge and an Oblique Shock Wave

*J.D. Parisse, Y. Burstchell, G. Tchien et al.*

Effect of the MHD Interaction on the Wall Heat Flux in Supersonic Flow around a Body

*S.V. Bobashev, N.P. Mende, V.A. Sakharov & A.A. Schmidt*

Investigation of Magnetohydrodynamic Effect on Steady State Argon Plasma Flow

*A. Knapp, N. Ono, D. Haag et al.*

Interaction of a Microwave-Generated Plasma with Flow Past a Hemisphere Cylinder at Mach 2.1

*D. Knight, V. Brovkin, D. Khmara et al.*

Drag Force Control via Asymmetrical Microwave Filament Location in a Supersonic Flow

*D. Knight, O. Azarova & Y. Kolesnichenko*

## **Session 24: RTO-WG043 / Gas Surface Interaction I**

Assessment of Aerothermal Heating Augmentation Attributed to Surface Catalysis in High Enthalpy Shock Tunnel Flows

*M. MacLean & M. Holden*

Catalycity of Zirconia and of ZrB<sub>2</sub>-Based Ultra-High Temperature Ceramics

*M. Balat-Pichelin, M. Passarelli, L. Scatteia & D. Alfano*

## **Session 25: High Speed Flow and Reentry Vehicles II**

Extension and Application of a Scaling Technique for Duplication of In-Flight Aerodynamic Heat Flux in Ground Test Facilities

*R.G. Verraar*

Navier-Stokes Computations of Reentry Flowfields with Coupled Surface Ablation

*D. Bianchi, E. Martelli, F. Nasuti & M. Onofri*

Estimation of Heat Transfer Near a Blunt Body by Approximate Analytical Method

*Yu.D. Shevelev & N.G. Syzranova*

Experimental and Numerical Studies to Evaluate Real-Gas Effects on Generic Models in the Free-Piston Shock Tunnel HIEST

*H. Tanno, M. Koderu, T. Komuro et al.*

Dynamic Instability of Reentry Space Capsules: A Numerical Investigation

*D. Depres & P. Tran*

## **Session 26: Facilities and Extrapolation to Flight**

Enthalpy Determination for Ground Testing Conditions in Plasma Wind Tunnel  
*H. Krassilchikoff & O. Chazot*

Characterization of a New Mach 9 Nozzle for the HEAT Hypersonic Wind Tunnel  
*D. Baccarella, A. Passaro, P. Caredda et al.*

Evaluation of the Contamination in Vacuum Due to Plume Effects and Materials Outgassing  
*B. Delamare, S. Palerm & J.-M. Carrat*

Review of European Aerodynamics and Aerothermodynamics Capabilities for Sample Return Missions  
*M. Bugel, P. Reynier & A. Smith*

## **Session 27: Multi-Disciplinary Simulation and Optimisation**

Simulation of Hydrogen Adsorption in Carbon Nanostructures  
*V.L. Kovalev & A.N. Yakunchikov*

Multi-Disciplinary Analysis and Optimization of Hypersonic Transport Aircrafts  
*R. Dittrich, J.M.A. Londo, G. Carrier et al.*

Transient Simulation of the DLR M3.1 Testbench: Methods and First Results  
*C. Manfretti & J. Sender*

## **Session 28: RTO-WG043 / Gas Surface Interaction II**

SiC Oxidation and Catalysis Modelling for Re-Entry Heating Predictions  
*M. Fertig, G. Herdrich & M. Auweter-Kurtz*

Theoretical Dynamics Study of Several Atomic and Molecular Oxygen Processes over a Silica Surface  
*R. Sayós, V. Morón, C. Arasa & H.F. Busnengo*

A Residual Distribution Method for Hypersonic Flows in Thermo-Chemical Nonequilibrium  
*A. Lani & H. Deconinck*

Rebuilding of New Experimental Tests on a Double Cone at Mach 9  
*A. Schettino, F. Battista, G. Ranuzzi & D. D'Ambrosio*

## **List of Participants**