

# **IAF Microgravity Sciences and Processes Symposium**

Held at the 75th International Astronautical Congress  
(IAC 2024)

Milan, Italy  
14-18 October 2024

ISBN: 979-8-3313-1207-7

**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.**

Copyright© (2024) by International Astronautical Federation  
All rights reserved.

Printed with permission by Curran Associates, Inc. (2025)

For permission requests, please contact International Astronautical Federation  
at the address below.

International Astronautical Federation  
100 Avenue de Suffren  
75015 Paris  
France

Phone: +33 1 45 67 42 60  
Fax: +33 1 42 73 21 20

[www.iafastro.org](http://www.iafastro.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

## TABLE OF CONTENTS

### **GRAVITY AND FUNDAMENTAL PHYSICS**

A Space Test of the Equivalence Principle Beyond MICROSCOPE .....	1
<i>Manuel Rodrigues</i>	
Exploring Black Holes with Hypothetical Tachyons: A Theoretical Odyssey Beyond the Event Horizon.....	5
<i>Zygmantas Vainauskas, John Toop-Rose, Samiksha Raviraja, Fiona Poda, Gaia Di Tommaso, Rachel Diamond</i>	
Neural Network Based Fixed-Time Control of a Free-Floating Space Manipulator .....	15
<i>Lei Jiang, Haiping Ai, An Zhu, E. Kaixin, Paofeng Zhou</i>	
Space Emulation Testbed for Close-Proximity Operations with Tumbling Uncooperative Targets .....	20
<i>Juan P. Garcia, Michael Bazzocchi</i>	
Dispersal Behavior of Celestial Surface Objects by Thruster Jet .....	29
<i>M. Yamakawa, T. Tokuoka, Y. Maru, S. Sawai, Y. Daimon, T. Ito, Y. Tsuda, O. Mori</i>	
Self-Assembly of Granular Gas and Three Dimensional Pattern Formation in a Microgravity Environment .....	38
<i>O. Hosei, Soichi Tatsumi</i>	
Prognosing How Time Passes in a Black Hole: A Study in Physics and Cosmology.....	45
<i>Tunzala Mammadova</i>	

### **FLUID AND MATERIALS SCIENCES**

A New Pressure Drop Correlation for Two-Phase Flow Under Microgravity Environment of Space Missions .....	49
<i>Maher Dhahri, Hana Aouinet</i>	
CFD of Space Station Thermal Comfort and Airflow Behavior Under Microgravity Conditions .....	57
<i>Hana Aouinet, Maher Dhahri</i>	
Enhancing Phase Change Material (PCM) Efficiency Through Timely Melting-Solidification Cycle Interruption.....	69
<i>D. Dubert, B. Seta, J. Massons, M. M. Bou-Ali, X. Ruiz, V. Shevtsova</i>	
Flow with Temperature Dependent Viscosity and Thermal Conductivity Over Radiative Needles .....	79
<i>Niba Kainat, Vincenzo Gulizzi</i>	
Qualification Test Campaign of Baridi-Sana Flight Model, an Innovative Two-Phase Flow Cooling System for Space Applications .....	83
<i>Andrea Delfini, Luca Guglielmetti, Riccardo Garofalo, Alessia Di Giacomo, Fabio Riccardi, Giuseppe Zummo, Luca Saraceno, Antonio Scotini, Paolo Marzoli, Fabio Santoni, Christian Ciri, Giancarlo Santilli, Munzer Jahjah, Andrew O. Nyawade, Charles Mwaniki</i>	

## **MICROGRAVITY EXPERIMENTS FROM SUB-ORBITAL TO ORBITAL PLATFORMS**

Centrifugal Casting of Wax-Based Fuel Grains in Microgravity: Preliminary Results from a Sub-Orbital Launch.....	93
<i>S. Dorrington, K. J. Stober, D. Rupasinghe, M. R. Apodaca, C. Mao, E. Romero, A. Blackman, U. Usua, D. Wood</i>	
Electrodynami c Regolith Conveyor Sub-Orbital Flight Experiment.....	101
<i>Aaron Olson</i>	
Impulse-Free Release Mechanism and Test Setup for Robotic Free-Floating Experiments on Parabolic Flights.....	108
<i>Philip Arm, Andrea Del Buono, Moriz Berclaz, Valerio Schelbert, Jorit Geurts, Fabio Bühler, Alexander Spiridonov, Fabian Tischhauser, Hendrik Kolvenbach, Marco Hutter</i>	
Welding Under Microgravity Conditions: Experimental Rationale, Background, and Approach by the Universidad Central De Venezuela Team, Awardee of the 2024 DropTES .....	115
<i>Eva Y.-W. Chang, Rock J.-S. Chern</i>	
Pulsating Heat Pipe Laboratory Tests for a Microgravity Sub-Orbital Experiment .....	118
<i>Larissa Krambeck, Kelvin G. Domiciano, Guilherme C. Zonta, Luis A. B. Arboleda, Sabrina Chichinelli, Marcia B. H. Mantelli, Luca Pagliarini, Fabio Bozzoli</i>	
Magnetic Surface Stress Pump Development Under Microgravity Conditions for Satellite Thermal Management .....	129
<i>Thomas Imhuelle, Benny Rievers, Marcel Vornholt, Michelina Zydel</i>	
Scientific Results of FerrAS - Innovations in Ferrofluid Pumping Systems for Microgravity Applications.....	135
<i>Frederik Junker, Janoah Dietrich, Bahar Karahan, Matteo Rossetto, Luis Weiß, Philipp Heuser, Nicolas Heinz, Christopher Vogt, Michael Steinert, Phillip Wolff, Philipp Kimmerle, Leon Habermalz, Alexander Wagner, Steffen Grossmann, Fiona Knoll, Erik Himmelsbach, Denis Acker, Elizabeth Gutierrez, Max Herkenhoff, Daniel Bölke, Saskia Sütterlin, Manfred Ehresmann, Felix Schäfer, Georg Herdrich</i>	
Enhancing Spacecraft Performance Through In-Space Microvibration Measurements .....	149
<i>Sven Thiele, Antonio Garcia, Tim Gust, Enes Basata, Tim Gersting, Marvin Grumme, Nils Goossens, Matias B. Körner</i>	
Suborbital Inexpensive Rocket (SIR) – Overview of the Project Results and Further Development Plan of PERUN Suborbital Rocket.....	156
<i>Adam Matusiewicz, Robert Magiera, Adam Synowiec, Kacper Zielinski, Rafal Ciania, Bartosz Moczala, Blazej Zielinski, Tomasz Chelstowski, Adrian Szwaba</i>	
Parameter Identification using Microgravity Experiments on Asteroid-Related Scenarios.....	165
<i>Samuele Vaghi, Alessia Cremasco, Luigi V. Delfanti, Iosto Fodde, Fabio Ferrari</i>	

## **SCIENCE RESULTS FROM GROUND BASED RESEARCH**

Influence of Gravity on Dynamics of Absorptive LiBr–water Solution .....	175
<i>P. F. Arroiate, M. Martinez-Agirre, M. M. Bou-Ali, V. Shevtsova</i>	
The Influence of Non-Uniform Heating from Below on the Dynamics of Floating Droplets.....	182
<i>Ilya Simanovskii, Alexander Nepomnyashchy, Antonio Viviani, Patrick Queeckers</i>	

Simulation of a Detonation Combustion Chamber.....	201
<i>E. V. Mikhachenko, V. V. Tyurenkova, F. Chen, Y. Meng</i>	
Theoretical Performance Evaluation of Rebound Mitigation of a Target Marker in a Microgravity Environment .....	207
<i>Tetsuya Kusumoto, Yasuda Shun, Yoshiki Sugawara, Osamu Mori</i>	
Experimental Analysis of vibrationally-Induced Fluidization of Lunar Regolith in Hoppers and Closed Containers.....	210
<i>Peter Watson</i>	
LEO Microfluidics Experiment Module.....	218
<i>Ruben Sanchez, Jonathan Bissonnette, Jiaxuan Zhao, Jacob Daigle</i>	

## **FACILITIES AND OPERATIONS OF MICROGRAVITY EXPERIMENTS**

Open Source Sounding Rocket-Based Free-Falling Platform to Conduct Reduced Gravity Research .....	230
<i>G. L. D. Pria, E. Almqvist, L. A. Parra, B. Åkerlund, A. Broström, V. Brückner, C. Buck, J. Gels, A. Hollmark, F. Höglund, A. Jakobsson, A. Korotkijs, A. Malmqvist, J. Mårtensson, T. Kuhn</i>	
Experimental Investigation of On-Orbit Fluid Management by using Varying-Gravity Experiment Rack on Space Station .....	238
<i>Qiu-Sheng Liu, Naifeng He, Yue-Qun Tao, Wei Gao, Jing-Chang Xie, Xiang Li, Yan-Lin Zhou, Jinzhong Xu, Ye Li, Yuanyuan Sun, Ying Liu</i>	
AMP: An Autonomous Sub-Orbital Microgravity Platform Mission Concept.....	242
<i>Adriano Parisi, Thomas Maxwell-Hodkinson</i>	
The GraviTower – Lunar Gravity Conditions on a Ground-Based Partial-Gravity Platform .....	250
<i>Merle Cornelius, Anna Becker, Marcel Bernauer, Thorben Könemann, Peter Von Kampen, Marc Avila</i>	
Future Possibilities for Gravity-Related Research and Training at Blue Abyss .....	255
<i>Vladimir Pletser</i>	
Analysis of Intra-Vehicular Robotic Free-Fliers and Their Manipulation Capabilities .....	259
<i>Monica Ekal, Federico Turchetti, Neal Y. Lii, Máximo A. Roa</i>	
Study on Capsule Release Device for Low Gravity Environment Test Facility .....	274
<i>I. Yu, Seungwhan Baek, Mansu Seo, Kwangkun Park, Jaehyun Shin, Yungu Choi</i>	
Orbital Labs: A Cost Effective AI Powered Microgravity Experimentation Platform for Future Research Markets in Latin American .....	276
<i>Mauricio Rodriguez, Carlos Rodríguez, María Del Barco, Esteban J. Sánchez, Giancarlo Vargas-Villegas</i>	

## **MICROGRAVITY SCIENCES ON BOARD OF SPACE STATIONS**

Material Science Onboard the International Space Station: Payload Operations at the Microgravity User Support Center MUSC .....	283
<i>Joachim Bonney, Jan Gegner, Angelika Diefenbach, Jean-Pierre P. De Vera</i>	

Flow and Heat Transfer Research in Space and Two-Phase System Experiment Platform on Aboard China Space Station.....	293
<i>Qiu-Sheng Liu, Yue-Qun Tao, Naifeng He, Jing-Chang Xie, Zhi-Qiang Zhu, Jing Xue, Ce Li, Lyu Wang, Yufeng He, Guo-Ning Liu</i>	
Tracking Trajectories of an Intruder Particle in a Three-Dimensional Granular Bed On-Board the Chinese Space Station .....	304
<i>Meiyi Hou, Ke Cheng</i>	
Grain Analysis Method of Metal Material for AM Levitated and Solidified in ISS.....	308
<i>Koei Kadoi, Chihiro Hanada, Yuji Mabuchi, Yuto Ueda, Yuta Kushiya, Hirokazu Aoki, Kanae Yoneda, Ryosei Saguchi, Motoko Yamada, Hisashi Sato, Yoshimi Watanabe, Shizuka Nakano, Shinsuke Suzuki</i>	
Can Acoustic Levitation Simulate Microgravity in Fluids? .....	316
<i>Rivaldo C. D. Aquino, Karen Cuba, Samir S. S. Rios, Johnny R. Milián, Avid Roman-Gonzalez</i>	
Preparing for Deep Space Exploration: Research Scenarios Beyond Low Earth Orbit.....	326
<i>Gourav Mohanan, Dhayashree Dhaya, Raja R. V. Madipadige</i>	
Experimental Investigation of Drop Evaporation in Two-Phase System Rack Aboard China Space Station.....	330
<i>Qiu-Sheng Liu, Yue-Qun Tao, Naifeng He, Qingxuan Xu, Jing-Chang Xie, Ce Li, Xuejiao Zhang, Jing Xue, Lyu Wang, Yifeng Wang, Yufeng He, Guo-Ning Liu</i>	
<b><u>LIFE AND PHYSICAL SCIENCES UNDER REDUCED GRAVITY</u></b>	
Operation of Life Science Facilities at the Microgravity User Support Center (MUSC) .....	334
<i>Maria Grulich, Katharina Hildebrandt, Angelika Diefenbach, Philipp Wever, Jessica Kronenberg, Jean-Pierre P. De Vera, Theresa Schmakeit, Cinzia Fantinati, Nico Maas</i>	
An Investigation on the Differences Between Beta Amyloid Aggregates Formed on Board the International Space Station and on Earth.....	344
<i>Franco Cardone, Elena Berrone, Cristiano Corona, Stefano Sirigu, Claudia Pacelli, Marco Sbriccoli, Alessandra Favole, Flavia Porreca, Clara Salciccia, Mariagrazia Severino, Carlotta Tessarolo, Serena Camerini, Marialuisa Casella, Marco Crescenzi, Anita Greco, Alessandro Crisafi, Rosa Sapone, Cesare Capararo, Paolo Cergna, Marino Crisconio, Serena Pezzilli, Simona Sennato, Francesca Scaramuzzo, Bruno Maras, Annalisa Manca, Giovanni Meli, Maurizio Pocchiari, Cristina Casalone</i>	
Advancements in the Mini Fluorescence Microscope Development: Progress and Prospects .....	349
<i>Kiira Tiensuu, Aditi Nerurkar, Jussi Lehti, Pasi Virtanen, Jouni Saari, Tero Säntti, Mika Hirvonen, Julián C. P. Piñeros, Elena Tcarenkova, Pekka Hänninen</i>	
AI/ML Powered Commercial Grade Human Performance System Enabling Standardized Space Biotech Research and Development.....	354
<i>Ioana Cozmuta, Siobhan Malany, Remus Osan, Brian Motil</i>	
IRMA Project: Developing Systems for Disease-Causing Bacteria Determination on Space Stations .....	367
<i>Diego A. D. Parapar, Roberto A. U. Incio, Martín S. S. Macalupu, Edir S. V. Castro, Maria N. M. Diaz, Gabriel L. D. L. Pretel, Nilton C. R. Vales, Lielka N. C. Huaman, Jeel Moya-Salazar</i>	
Microgravity Study of Vine Robot: A Lightweight and Compact Alternative to Conventional Space Robots.....	374
<i>Nathalie V. Lagunes</i>	

## **IN-SPACE MANUFACTURING AND PRODUCTION APPLICATIONS**

In-Space Manufacturing - 2024 Industry Survey, Trends, Economics and Enablers.....	383
<i>Erik Kulu</i>	
In-Space Manufacturing - Facts and Myths: Lessons Learned from ZBLAN Optical Fiber Manufacturing .....	417
<i>Ioana Cozmuta, Remus Osan, Brian Motil</i>	
Manufacturing Experiments Achievement Sharing in Microgravity and Future Prospects by the Key Laboratory of Space Manufacturing Technology.....	429
<i>Yifei Liu, Haiyun Sun, Gong Wang</i>	
Manufacturing Better Drugs in Microgravity.....	443
<i>Kenneth Savin, Stephen Tuma, Anne M. Wilson, Molly Mulligan</i>	
A Path Towards Printed Electronics in Space: Transfer and Evaporation of Colloidal Droplets in Microgravity .....	451
<i>Weibin Li, Chen Zhang, Yuren Wang</i>	
An Experimental Investigation of Microgravity Conditions on FDM-Based In-Space Additive Manufacturing .....	455
<i>Angela Huang, Zheng H. Zhu</i>	
Additive Manufacturing of Lunar Regolith via Resin-Based Binder and Material Extrusion Method for High-Performance In-Space Manufacturing on the Moon.....	469
<i>Tongcai Wang, Guangshuai Gu, Rihan Zhang, Gong Wang</i>	
Development of In Space Manufacturing Capabilities for the Production of Protein-Based Artificial Retinas .....	477
<i>Jordan A. Greco, Daniel B. Sylva, Hope A. Sylva, Krishna K. Dixit, Ashley J. Johnson, Robert R. Birge, Nicole Wagner</i>	

## **INTERACTIVE PRESENTATIONS - IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM**

Compact Germplasm Bank (CGB): A Tool to Assist in Microgravity Studies of in Vitro Plants in Space and on Earth .....	484
<i>Paulo Rodrigues</i>	
Effect of Corrosion Processes on the Performance of Screen Phase Separators in Reusable Space Systems with Long Service Life.....	489
<i>Anatolii Lohvynenko, Oleksandr Minai</i>	
Microalgae Cultivation Facility with Integrated Raman Spectroscopy: A Path Towards Optimized Bioproduction in Microgravity .....	504
<i>Vaclav Havlicek, Martin Lontras</i>	
Microgravity Testing of a Newly Developed Air-Breathing Electrostatic Thruster .....	508
<i>Akram Abdellatif, Omar Elsherbiny</i>	
Revolutionizing Protein Crystallization for In-Space Manufacturing: Microgravity's Influence on Fluid Dynamics, Experimental Techniques, and Biological Implications. ....	512
<i>Rina Choudhary, Akshat Gupta, Atharva Barbudhe</i>	

In Space Opportunities for Biomedical Manufacturing Pharmaceutical Development, Biomanufacturing, and Additive Manufacturing .....	522
<i>Shawna Pandya</i>	
Machine Learning Optimized Process Control and Yield of Artificial Retina In-Space Manufacturing .....	532
<i>Ioana Cozmuta, Nicole Wagner, Remus Osan, Brian Motil</i>	
In-Space Manufacturing of Functional Sensors.....	538
<i>Justin Astacio, M. L. S. Johann, Zachary Stein, Leonardo Facchini, Janine Wischek, Marion Bartsch, Michael Kinzel, Seetha Raghavan</i>	
Hybrid Additively Manufactured Satellite Technology Experiments .....	545
<i>Christopher Hartney</i>	
Microgravity Experiments and Their Transformative Influence on Space Exploration: A Comprehensive Review of Current Progress and Future Prospects .....	552
<i>Amin Ahmadov</i>	
Low-Cost Payload for Space Biology Experiments in Parabolic Flights .....	557
<i>Florence P. Basubas</i>	
Bridging the Cosmic Gap: Bioengineered Plants and Carbon Management in Microgravity .....	564
<i>Telman Mammadov</i>	
Biomanufacturing in Low Earth Orbit.....	569
<i>Aaron Rogers, Kenneth Savin, Molly Mulligan</i>	
G-SPACE: An AI/ML Microgravity DOE Platform to Enable Profitable in Space Manufacturing .....	576
<i>Ioana Cozmuta, Remus Osan, Brian Motil</i>	

### **LATE BREAKING ABSTRACTS (LBA)**

A Computational Analysis of a Bio-Fabricated Bone Under Micro-Gravity.....	587
<i>Arjun Dabas, Lavleen Sharma, Aditi Chayani, Prathamesh Minde, Harshita Singh, Raahil Sheikh, Rutuparna Nayak</i>	

### **Author Index**