Abstract Book

14th Asian Microgravity Symposium - 2024

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ABSTRACT BOOK

14th Asian Microgravity Symposium

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Plenary talk

14th Asia Microgravity Symposium 2024

AMS001 Plenary Talk 1:

Indian space roadmap - opportunities for microgravity research

Shri Dinesh Kumar Singh, Distinguished Scientist, HSFC

Indian space programme has evolved from the application-focussed theme of the inception of space programme in the country, to the current forward-looking approach as evident in the Indian space roadmap. India aspires for continued presence in low-earth orbit beyond Gaganyaan mission, carry out more deep space missions to the Moon, asteroids, Mars and Venus, eventually meeting the two major targets of lunar sample return mission by the year 2035 and human landing on the Moon by the year 2040. Space would be one of the major contributors for the national ambition of overall development by 2047, marking 100 years of Indian independence. This space roadmap offers tremendous opportunities for the microgravity research in the country. The national efforts fronted by ISRO would channelize the expertize and capabilities available in various national academic institutions, research labs and the industry. ISRO looks forward to create the necessary ecosystem involving various stakeholders in the field of microgravity research, and create the necessary platforms and qualified human resource for ground and space based microgravity research. This would also promote more collaborative efforts involving Indian entities, thus enhancing India's contribution in the international efforts to further the knowledge in this niche area of research.

AMS670 Plenary Talk 2:

Study for materials sciences using electrostatic levitation

Dr. Geun Woo Lee -

Frontier of Extreme Physics, Korea Research Institute of Standards and Science,Applied Measurement Science, University of Science and Technology (UST),Republic of Korea

Electrostatic levitation (ESL) is a fascinating tool that can provide many advantages (e.g., uncontaminated and precise measurements, unlimited heating temperature, achieving deep metastability,and so on) for studying materials sciences in space and on earth. Thanks to Dr. Rhim, who created ahigh temperature ESL in 1993, tremendous researches have been carried out and many scientificmysteries have been resolved in physics, materials sciences, chemistry, and so on. Specially, ESL hasshown a great capability to measure thermophysical properties of liquid materials, which is necessaryto study crystal nucleation and growth, glass formation, the formation of microstructure on solidificationand so on. Moreover, the combination of ESL with scattering techniques has extremely enhanced themeasurement capability from macroscopic to microscopic viewpoints in materials sciences, which can provide fundamental understanding of the nature. Furthermore, ESL studies have stimulated MDsimulation effort to reveal hidden propertiesin supercooled or ultrahigh temperature liquids. Also, recentstudies have shown that ESL can be extensively used in chemical and biological sciences by controllingconcentration.In this talk, we will briefly introduce the history of ESL development and containerlessmeasurementusing ESL. In particular, we will show how accurate measurements of the thermophysical properties has been improved in a wide temperature range in Korea Research Institute of Standards and Science. Inaddition, we will demonstrate how the combination of ESL with scattering devices impact onunderstanding phase formation and phase transition pathways with various materials.

AMS003 Plenary Talk 3:

Progress and prospect of space science and utilization of China Space Station

Dr. Cong-Min Lyu
Chinese Academy of Sciences

This report provides a comprehensive overview of the recent progress and future prospects in the fields of science and utilization of the China Space Station(CSS). It begins with an outline of the science facilities and their supporting capabilities of the CSS. Subsequently, the report details the scientific objectives and research layout of the CSS so as to support long-term space scientific research. The report then presents recent science experiment progress and major scientific results in the fields such as space life science and space materials science etc,. Following the highlights, the report elaborates on scientific project solicitation and future prospects, explaining the process of applying for a scientific project, participating in future missions of the CSS. Finally, the report outlines how China collaborates with global partners through bilateral agreements or multilateral framework to advance space exploration and scientific research.

AMS999 Plenary Talk 4:

Role of Microgravity Utilization in Combustion Research

Dr. Osamu Fujita

Division of Mechanical and Aerospace Engineering, Hokkaido University, Japan

Combustion phenomena are accompanied by rapid heat release, resulting in large temperature anddensity gradients. Consequently, combustion is always influenced by buoyancy-induced flow undernormal gravity, which complicates understanding the elementary processes involved in combustion. Toovercome this challenge, a microgravity environment is a powerful tool for gaining better insights intocombustion phenomena, and many research activities have utilized microgravity in this field. In thisplenary lecture, general information about methods for microgravity combustion research will beintroduced, including the drop-tower in Hokkaido, Japan, constructed in 2006, and the Solid CombustionExperimental Module (SCEM), currently in operation onboard the ISS/KIBO module in orbit.Furthermore, the essential role of microgravity in combustion research will be discussed from bothscientific and practical perspectives. Several ongoing and completed research projects utilizingmicrogravity in Japan will also be introduced. One of the ongoing projects is the FLARE (FlammabilityLimits at Reduced Gravity Experiment) project, in which the author’s group is involved to study flamespread and ignition phenomena of electric wires. The latest results, including modeling flame spreadover electric wires and numerical simulations of overloaded wire ignition, will be presented as examplesof the contributions microgravity research has made to combustion studies. This research is partiallysupported by the Japan Space Exploration Agency (JAXA) under the FLARE project.

Plenary Talk 5:

AMS002 **Research highlights of JAXA Kibo utilization**

Dr. Izumi Yoshizaki, JAXA Japan

JAXA started microgravity experiments in the 1990s. After much trial and error, JAXA now conducts experiments on the ISS from various fields proposed by researchers, and more than 2600 research papers have been published. In this presentation, the experiments and facilities of the ISS/Kibo experiments will be introduced as well as future plan.

AMS236 Plenary Talk 6:

The scientific vision of the project wgFBCE-CSS

Dr.Jian-Fu Zhao

CAS Key Laboratory of Microgravity, Institute of Mechanics, Chinese Academy of Sciences,China

Greatly increases of scope, complexity, and duration of future space missions, particularly mannedmissions to Moon, to Mars, and to asteroids, are expected. Associated with these challenges are unprecedented increases in both power requirements and heat dissipation demands. Advanced two-phase systems with high heat transfer performance by utilizing gas-liquid phase change will be one ofthe best candidates. On the other hand, there is a large density difference between the gas and liquidphases, which can cause significant changes in the performance of gas-liquid two-phase systems indifferent gravity environments throughout the entire cycle of space missions. Thus, detailedunderstanding of the influence of reduced gravity on two-phase flow and heat transfer is required. The project wgFBCE-CSS is then proposed to study the heat transfer performance of flow boiling andcondensation in a wide range of simulated gravity levels from microgravity to 2g utilizing the VariableGravity Rack (VGR) aboard the China Space Station (CSS). It will also serve as a new integrated two-phase flow boiling and condensation facility for the CSS, in addition of the Two-Phase System Rack(TPSR), to meet the needs of the research community at large in obtaining two-phase flow and heattransfer data, with a particular focus on those obtained in adjustable simulated gravity conditions. Keyobjectives of the project wgFBCE-CSS are to: (a) obtain flow boiling and condensation heat transferdatabases in long-duration, wide-range, and really adjustable gravity conditions; (b) developexperimentally validated, mechanistic models for key parameters such as friction pressure drop, heattransfer coefficient, and CHF, as well as the gravity-independent model based on multi-parameter fusion;(c) reveal the instability mechanism of the two-phase system and the influence of gravity on systemstability. The lecture will firstly review published literature concerning two-phase flow and heat transferin reduced gravity, with a particular focus on gravity effect. Then, the R&D progress relevant with theprojectwgFBCE-CSS will be introduced.

Keywords:wgFBCE-CSS; Flow boiling; Flow condnsation; Two-phase systems; Gravity-independentcriterion.

AMS789 Plenary Talk 7:

High Temperature Materials Racks and Materials Research Progress inChinese Space Station

Dr. LIU, Xuechao
Shanghai Institute of Ceramics, Chinese Academy of Sciences

In Chinese Space Station, “High-Temperature Materials Rack (HTMR)” and “ContainerlessMaterialRack (CMR)” have been developed for materials research. The core module of HTMR is a four-heating-zone furnace designed for materials processing. It can be heated up to 1600°C. 16 sample cartridgeswith φ26mm×380mm can be automatically and accurately exchanged by the sample managementassembly in this system. Based on this feature, it can cover as wider as possible the different kinds ofmaterials by changing the furnace to adapt the materials processing demands. The maximum processinglength of the sample is 160mm. Directional solidification can be carried out by moving the heating zone along the axial direction, with the moving rate ranging from 0.5 to 200mm/h. In addition, the solidifyingprocess can be visualized with in situ X-ray radiography observation method by one special module.The resolution can reach 5um at 20fps for X-ray in situ characterization. The CMR can melt materialsamples with melting points near 3000K and cool them at various degrees of undercooling to obtaindifferent metastable phases. It employs semiconductor and oxide lasers for melting both high-temperature metal and inorganic non-metallic materials, with the semiconductor laser's maximum output power reaching 300W. Containerless experiments can be conducted in a vacuum of 10-3 Pa and atconditions of 3 atm under argon gas. The CMR can support experiment with a single sample boxcontaining 29 samples, each sample with a diameter of approximately 3 mm.

These two facilities have been serving in space for materials experiments in Chinese Space Station sincelaunched (HRMR launched on 31 October 2022, CMR launched on 29 April 2021). Up to now, totallymore than 20 projects have been carried out in microgravity and returned more 30 boxes samples fromChinese Space Station.

AMS004 Plenary Talk 8:

Agency Current and future microgravity activities of the German Space Agency in physical sciences

Dr.Tobias Saltzmann

The German Space Agency at DLR manages the German Space Program. This program integrates the German participation in the ESA programs, the activities in the National Program as well as the R&D activities of the DLR research institutes.

As one core element of the German space activities, Research under Space Conditions covers life and physical sciences utilizing space conditions such as weightlessness and space radiation. The tasks of this unit can be divided into three major elements:

(i) provision of microgravity platforms (e.g., drop tower, parabola flights and sounding rockets),

(ii) development of flight hardware, and

(iii) preparation, execution, and analysis of microgravity experiments.

The Microgravity Sciences Program deals with gravity-dependent effects on physical and chemical processes. For life sciences, in addition to gravity-dependent effects, the influence of space radiation on living systems is being surveyed. Germany`s National Space Program aims at gaining scientific knowledge by addressing fundamental questions in physical as well as life sciences, fostering new technological developments and to reveal new application potentials by both fundamental as well as application-oriented research, especially utilizing the ISS and its subsequent low earth orbit (LEO) platforms. A special focus is put on scientific activities related to human and robotic exploration and the maturation of new space technologies.

In this talk, major German research topics and on-going facility developments in life as well as physical sciences for the ISS and other microgravity platforms are presented. A focus will be put on physical experiment hardware developments for LEO applications.

Keywords: German space agency; microgravity science; experiment hardware

AMS257 Plenary Talk 9:

Mammalian reproduction and embryonic development: from ground to space

Dr. LEI, Xiaohua - Shenzhen Institute of Advanced Technology,
Chinese Academy of Sciences

The advancement of space technology has increased human exploration of outer space, offering the potential for space settlement as a solution to Earth's resource crisis. However, reproductionand offspring development in space present significant challenges. Recent progress in early mammalianembryo studies, including human embryos, has been crucial for assisted reproductive technologies andregenerative medicine. Ground-based experiments using in vitro fertilization, embryo culture,cryopreservation, thawing, and gene editing have allowed researchers to investigate key stages ofmammalian embryo development from fertilization to implantation. These studies have revealedfundamental mechanisms of cell division, differentiation, and morphogenesis, with CRISPR/Cas9 geneediting enabling precise regulation of gene expression to uncover specific gene functions. In spaceresearch, since the 1990s, NASA and the Russian Federal Space Agency (RKA) have conductedspaceflight pregnancy experiments with Norwegian rats. These studies found that early pregnancy ratembryos sent into space could not sustain development or produce viable offspring, while mid-to-latepregnancy females could deliver live pups upon returning to Earth, indicating a detrimental impact ofthe space environment on early embryonic development. In 2016, using the SJ-10 recoverable scientificsatellite, We have successfully developed mouse 2-cell embryos into blastocysts in space conditions forthe first time. However, the development rate and quality were significantly lower than those of theground control. In 2021, Japanese scientists confirmed that cryopreserved mouse 2-cell embryo coulddevelop into blastocysts in space, albeit with lower development rates and poorer quality. These findingssuggest potential risks to embryo development and reproductive functions in humans and mammals dueto the space environment. Thus, understanding how space environment factors affect early mammalianembryonic development and offspring health, the molecular mechanisms involved, and the potential forartificial intervention to mitigate these impacts are critical scientific and technical challenges. As theChina Space Station (CSS) enters its operational and developmental stages, more researchers will havethe opportunity to study mammalian embryonic development. Future results will provide newknowledge and technological support for mammalian reproductive health and life creation in space,while also enhancing reproductive and developmental research on Earth.

Keywords: Reproduction;Embryonic development; Space environment; Microgravity; Radiation.

AMS981 Plenary Talk 10:

Microgravity Research at ZARM's Drop Tower Facilities

Dr.ThorbenKönemann

ZARM Fallturm-BetriebsgesellschaftmbH ,

ZARM Drop Tower Operation and Service CompanyBremen, Germany

The Center of Applied Space Technology and Microgravity (ZARM) founded in 1985 is part of theDepartment of Production Engineering at the University of Bremen, Germany. ZARM is mainlyconcentrated on fundamental investigations of gravitational and space-related phenomena underconditions of weightlessness as well as questions and developments related to technologies for space.At ZARM, about 100 scientists, engineers, administrative staff, and many students from differentdisciplines are employed.

Today, ZARM is one of the largest and well-known research center for space sciences and technologiesin Europe. With a height of 146 m, the Bremen Drop Tower is the predominant facility of ZARM andalso the only drop tower of this kind in Europe. ZARM's ground-based laboratory offers the opportunityfor daily short-term experiments under conditions of high-quality weightlessness at a level of 10-6 g.Scientists may choose up to three times a day between a single drop experiment with 4.7 s in simple freefall and an experiment in ZARM's worldwide unique catapult system with up to 9.3 s in microgravity.Since the start of operation of the drop tower facility in 1990, over 10,000 drops or catapult launches of more than 300 different experiment types from various research fields have been accomplished so far.In addition, more and more technology tests have been performed under microgravity conditions at theBremen Drop Tower, in order to prepare single space instruments or appropriate space missions inadvance.

Since the beginning of the year 2022, the GraviTower Bremen Pro represents ZARM's new next-generation drop tower system, which makes use of a rail-guided rope drive being able to perform up to20 experiments per hour. Its technology is based on a commercial hydraulic winch system with morethan 4000 hp of engine power that moves a rail-guided drag shield in a 16 m high tower, upwards anddownwards. With its novel and sophisticated Release-Caging-Mechanism (RCM), the actively drivenGraviTower located in the integration hall of the Bremen Drop Tower is capable of controlling heavypayloads of up to 500 kg in a very smooth and precise manner. The RCM developed and patented byZARM also enables a fast and reliable decoupling as well as re-coupling of the experiment capsuleinside the drag shield. Due to the fact that the standard capsule of the Bremen Drop Tower is utilizedfor GraviTower operation, high synergy effects are given between both, the Bremen Drop Tower andGraviTower Bremen Pro. It means a simple switching between all operation modes (drop, catapult, orGraviTower) with the same experiment capsule. In conclusion,

the GraviTower complements theBremen Drop Tower and offers an excellent alternative to perform dedicated microgravity research.Even partial-gravity experiments are also feasible in ZARM’s second drop tower facility since thebeginning of the year 2024.In this paper, we will give an overview about ZARM’s drop tower facilities and related microgravity /first partial-g experiments as well as ongoing development projects.

Keywords: microgravity; partial-gravity; drop towers; research platforms

Venue :Auditorium **Session 1A: Life Science and Biotechnology-1** Dec-03

AMS573 **Past, Present, and Future of Ground-Based Microgravity Simulation Systems: Focusing on the 3D Random Positioning Machine (RPM)**

Han Sung Kim[1]*
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A clinostat is a system designed to continuously rotate an object around an axis perpendicular to theforce of gravity, thereby minimizing the influence of gravity by equalizing its vector across thehorizontal axis. In contrast, the 3D Random Positioning Machine (RPM) employs a more intricaterotational pattern, enabling the elimination of gravity from multiple angles and offering a more precisesimulation of microgravity conditions. The 3D RPM has been applied across various fields, includingcell biology, tissue engineering, microbiology, botany, and human physiology, to study the effects ofmicrogravity.

Traditionally, the 3D RPM has been predominantly used for cell and plant culture to investigate theimpact of space environments. However, we have developed an innovative device aimed at advancingcountermeasure research for space environments by enhancing the capabilities of the 3D RPM. Notably,we have developed the world's first system that can simulate microgravity while delivering continuousultrasound stimulation during cell culture. This system has allowed us to explore the efficacy ofultrasonic stimulation as a potential countermeasure to space-induced bone loss.

Recent research highlights the advantages of microgravity for the development of antibody-basedtherapeutics, as it promotes more efficient protein crystallization than on Earth, facilitating moreaccurate analysis of protein tertiary structures. As a result, space biotechnology is gaining increasingrelevance, not only for space exploration but also for the biomedical industry, where the unique aspectsof the space environment can be harnessed.Future directions for the development of RPM should go beyond space medicine to develop customizedsystems for pharmaceutical and biomedical applications by exploiting the phenomenon of microgravity.Our research team is currently focused on enhancing the design of our externally stimulated RPM. This next-generation device will be employed in studies involving cancer cells and stem cells, with the goalof developing targeted therapeutic strategies for specific diseases.

Keywords: Clinostat; 3D RPM; Microgravity; Space biotechnology

AMS994 **Protein nanocages promote osteogenesis and prevent cytoskeletal damage from oxidative stress induced under microgravity conditions**

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The microgravity conditions and cosmic radiation pose a significant threat to musculoskeletal health,particularly bone mass in space. However, the critical mechanism underlying space-induced bone lossand its relation with cellular oxidative stress is unclear. Recent studies showed that the administrationof myogenic or bone-loss-reversing drugs can prevent bone loss in astronauts. However, they face severe

limitations such as poor therapeutic efficacy and side effects causing metabolic defects like insulinresistance, hyperglycemia, etc. Herein, we have unraveled that simulated microgravity (SMG) inducesreactive oxygen species (ROS) which affects osteoblasts and downregulates osteogenic genes. The ROSalso damaged cytoskeletal actin and microtubule filaments in osteoblast cells. Further to scavenge theROS in an effective manner, we designed protein-zein nanocages in the size range of 100-200 nm. Thezein nanocages loaded with a chimeric non-enzymatic cocktail including ascorbic acid, resveratrol,luteolin, Coenzyme Q, and glutathione (ZNAC) demonstrated excellent stability, biocompatibility, andantioxidant properties compared to free drugs. The ZNAC significantly reduced the SMG-inducedgeneration of reactive oxygen species in osteoblast cells cultured under SMG conditions. It upregulatedthe alkaline phosphatase activity and expression of osteogenic genes like RUNX2, Col1A1, ALP, andBSP promoting osteogenesis under microgravity conditions. Moreover, it also prevented cytoskeletalactin and microtubule filament damage in the osteoblast cells under SMG conditions. Taken together,our findings suggest that ZNAC will be a promising candidate in the field of bone regeneration andcould revolutionize the management of astronauts’ health during space missions, instilling hope for ahealthier future in space.

Keywords: Cosmic radiation; Cellular oxidative stress; Simulated microgravity (SMG); Osteogenesis.

AMS185 **Mechanotransduction and gene expression in microgravity: an integratedMechSigFlow pipeline for bio-fluid dynamics and T-cell signaling**

Anirudh Murali [1, 2,] Gauri Panditrao[1,] Ram Rup Sarkar [1, 2*]

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Space exploration has long intrigued humanity, and recent technological advancements havedrastically reduced launch costs, fueling a significant increase in space research and human spaceflightendeavors. Despite these advancements, the unique environment of space introduces several risks dueto the effects of reduced gravity on astronauts and leads to various physiological changes, includingbone demineralization, musculoskeletal atrophy, space anemia, and immune dysfunction. Compromisedimmune function in space manifests as heightened allergic responses, decreased leukocyte counts,impaired leukocyte morphology and activation, diminished macrophage activity, and irregular secretionof interleukins and chemokines.

In the microgravity environment, cells encounter a complex array of stressors, including shearstress induced by blood flow and alterations in gravitational forces. While T-cells primarily reside withintissues, their circulation through the bloodstream and lymphatic system is crucial for reaching targetsites. These fluidic environments subject cells to mechanical stresses that necessitate adaptive responsesmediated by mechanotransduction. Despite extensive research, a comprehensive understanding of howstress-induced mechanotransduction influences downstream gene expression remains elusive. Toelucidate the intricate interplay between bio-fluid dynamics (blood/lymph), T-cell behavior, andsubsequentmechanotransduction pathways under microgravity conditions, an integrated computationalframework was developed. This framework combines a Computational Fluid Dynamics (CFD) model,which quantifies bio-fluid flow, T-cell deformation, and surface forces under altered gravity, with amodified Python-based Signal Flow Analysis model to investigate signal transduction mechanisms.

This integrated approach, termed the MechSigFlow pipeline, simulates gravity-induced mechanotransductionwithin T-cell signaling networks. The methodology integrates cell surface force data with transcriptomicinformation and network topology, facilitating the estimation of gravity-induced mechanical signal flowthrough a signal propagation algorithm. Computational perturbation experiments were conducted onmechano- and gravi-sensitive receptor proteins using the cell surface forces derived from the CFDmodel. These perturbations revealed significant alterations in the flow of force-induced signals withinthe network. Statistical verification of these changes indicated modifications in gene expression, whichwere validated against transcriptomic datasets. The pipeline successfully predicted 63% of network-associated common genes, achieving 75.71% accuracy for downregulated genes and 43.41% forupregulated genes. Data analysis revealed increased force-induced signal flow in pathways associatedwith the actin cytoskeleton, RAS pathway, and shear stress pathways, which were upregulated.Conversely, signal flow through significant proteins in the Toll-like receptor (TLR), extracellularmatrix-receptor (ECM-receptor), nuclear factor kappa B (NFKB), and mitogen-activated protein kinase(MAPK) signaling pathways were downregulated. The MechSigFlow pipeline identified critical motifsfor the flow of force-induced signal and amplification within the network, including proteins such asYAP1, STK3, LATS2, PTK2, AKT3, Ca2+, CHUK, PIK3CA, FOS, and SRC. These mechanosensitive proteins operate through a three-layered system: small molecules (e.g., Ca2+), signaling layer proteins(e.g., AKT3, PIK3CA, RAP1, RRAS2, MAPK8, RAC1), and transcription factors (e.g., NFKB1, FOS,YAP1) that ultimately drive gene-level changes. Restoring cellular homeostasis may be achieved byblocking or reversing signal flow or altering the basal activity of small molecules.

Keywords: Microgravity; T-cell; Signalling pathways; Mechanotransduction; Computationalmodeling.

AMS195 Development of 3D RPM Applicable to Ultrasound Stimulation and Evaluation of the Effects of Microgravity and Ultrasound Stimulation on MC3T3-E1 Cells

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The human body undergoes significant changes due to space environments such as microgravity andspace radiation. In particular, long-term space missions lasting several months or more are known to cause severe damage to the musculoskeletal system. Clinically, it has been reported that astronauts canexperience up to 19% bone loss during extended space missions. Low-intensity ultrasound stimulation has been extensively studied for fracture healing and is widely used clinically. We developed a RandomPositioning Machine (RPM) to simulate microgravity on Earth and used it to apply ultrasoundstimulation and observe changes in MC3T3-E1 cells. While existing RPMs focus on simulatingmicrogravity, there has been no research aimed at mitigating the changes induced by microgravity.Therefore, we developed a device that simulates microgravity while providing mechanical stimulationand conducted experiments.

Our developed 3D RPM is equipped with an ultrasonic transducer to both simulate microgravity andapply stimulation. Using this device, we evaluated the changes induced by microgravity at the cellular level and whether ultrasound stimulation could suppress these changes. Osteoblastic cells were culturedin dishes, and after one day, the dishes were filled with L15 1:1 medium and sealed. The RPM and theRPM with ultrasound groups were mounted and exposed to microgravity for one or two days. Afterapplying the ultrasound gel, daily ultrasound stimulation was administered using the transducer. At theend of the experiment, WST assay was performed, followed by preparation for Western blot and RT- PCR analyses.

The cell viability results showed that the cell viability in the ultrasound group increased compared tothe static and RPM groups, confirming that ultrasound stimulation enhances cell survival not only onEarth but also in a microgravity environment. Gene expression related to osteogenesis was also analysedby RT-PCR, revealing that ultrasound stimulation had an overall positive effect. Additionally, genesrelated to cell differentiation, including Col11a1, Bmp8b, OGN, RANKL, and OPG, indicated thatultrasound stimulation restored osteoblast differentiation. Subsequently, Western blot analysis wasconducted to assess protein expression. Integrin β3 and FAK, important targets for early tumor diagnosisand therapy, were increased in the RPM applied with ultrasound group. FAK expression significantlydecreased in the RPM group on day two but was recovered by ultrasound stimulation. Proteins such asAkt and ERK, which play crucial roles in muscle formation and stem cell regeneration, were alsoincreased in the RPM applied with ultrasound group. These results showed that ultrasound stimulationis transmitted through the integrin β3-FAK-Akt-ERK pathway. Therefore, these results suggest that non-pharmacological methods using ultrasound can inhibit bone loss in a microgravity environment.

Keywords: Microgravity; 3D RPM; Ultrasound stimulation; MC3T3-E1

AMS263 **Microbial Online Detection Experiment on Chinese Space Station**

Fangwu Liu[1]*, Zihe Xu[1], Dazhao Xu[1], Weibo Zheng[1], Tao Zhang[1], Guanghui Tong[1], Tianqing, Dingkun

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The Chinese Space Station has transitioned from the construction phase to the operational phase.Compared to previous satellite platforms, the space station provides more advanced experimentalequipment, more abundant experimental resoures, more frequent experimental opportunities, and moreflexible experimental operation modes. This has provided unprecedented development opportunities forChinese space life science. The long-term presence of astronauts provides essential support forexperimental operations, including the installation, transfer, low-temperature freezing, and return ofexperimental samples.

The space station operates under aerobic sealed conditions, providing suitable life support conditions for astronauts while also providing an environment for the proliferation of internal microorganisms.Long-term space missions require monitoring potential pathogens and microbial contamination, whichis crucial for the health of astronauts and the reliable operation of space equipment. To meet this urgent need, the Chinese Space Station is equipped with an online microbial detection module. This moduleidentifies the presence and types of microorganisms through culture observation and nucleic acidamplification detection methods. The culture observation method involves astronauts manually addingsamples collected in the sampling module to the culture medium for cultivation, followed by automatic imaging of the colonies on the culture medium. Microorganisms are identified based on theirmorphology, color, and other characteristics on the culture medium. After identification, a UVsterilization lamp is activated to sterilize the microorganisms on the culture medium. The nucleic acidamplification detection method utilizes loop-mediated isothermal amplification (LAMP) for isothermalnucleic acid amplification and detection technology. It amplifies specific microbial nucleic acidfragments and simultaneously detects changes in fluorescence values during the amplification processto determine the presence and quantity of specific microorganisms.

Keywords: Space Life Science, Space Biology, China Space Station, Microbial Detection

AMS308 **Advancing in-Space biomanufacturing of Bacteriorhodopsin in Halobacterium salinarum under microgravity by using oxidative stress based strategy**

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[1]Department of Biotechnology, Bhupat and Jyoti Mehta School of Biosciences,
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Biological production in microgravity presents promising opportunities, yet the effects of microgravityon microbial growth and metabolism differ among species, and the underlying mechanisms remainpoorly understood. Gaining deeper insights into these effects is crucial for both basic research andapplied biotechnology. Reactive oxygen species (ROS), including hydroxyl radicals, nitric oxide, andsuperoxide, are vital in cellular signalling and defence, with their intracellular steady-state levels nowrecognized as reliable markers of cellular oxidative stress. Our research has shown that ROS can increasemicrobial productivity by over 400% 1,2,3. However, their influence under microgravity conditions isnot well understood. This study aims to investigate the impact of oxidative stress on the metabolism ofHalobacteriumsalinarum under simulated microgravity. The goal is to improve in-spacebiomanufacturing by modulating cellular reactive species homeostasis. H. salinarum is chosen for itsability to produce bacteriorhodopsin, a photosensitive transmembrane protein with various applications,including the potential development of advanced artificial retinas in space 4,5. The research explores thedynamics of ROS and their effects on H. salinarum metabolism under different gravity conditions,utilizing a Rotatory Cell Culture System (RCCS) for experiments and metabolic modelling techniques.Initial results indicate an 18% reduction in maximum cell concentration under simulated microgravitycompared to Earth’s gravity (1g). The study focuses on oxidative stress as a possible explanation forthis difference by examining cellular redox homeostasis components such as ROS and antioxidants.

Further research will involve adjusting cellular ROS levels and analyzing growth and productivity acrossdifferent gravity conditions. By integrating these approaches, this study aims to develop a novel ROS-based strategy to enhance productivity in microbial biomanufacturing for space applications.Understanding the intricate relationships between microgravity, oxidative stress, and microbialmetabolism offers significant potential for advancing biotechnological efforts in space exploration andutilization.

Keywords: Halobacterium, Oxidative stress, ROS, Space Biomanufacturing, Simulated microgravity.

AMS652 **Mechanisms of gravity sensation: Influence of spaceflight and contact stimuli on neuromuscular system and gene expression in C. elegans**

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Spaceflight experiments have shown that altering gravity can affect many biological processesincluding neuromuscular, skeletal, sensory and cardiovascular systems. However, how the bodysenses alteration in gravity and then directs various changes in the body is not yet clear. Such gravitysensing mechanisms may stem from cell autonomous mechanisms or may be centrally controlled by asmaller set of cells that can sense gravity changes. The nematode C. elegans is a well-known geneticmodel animal that has been used in many spaceflight experiments and amenable to laboratorysimulated microgravity experiments. C. elegans muscular, nervous system, developmental, transcriptional and proteomic changes have been observed during spaceflight similar to other animals.In this talk, we will present results from recent spaceflight experiments aboard the ISS to address how the nematode may be perceiving changes in gravity. We will demonstrate how muscles and neuronare altered by microgravity at the cellular and transcriptional level during the lifetime of the animal.

We will also present evidence that the loss of contact stimulation and altered mechanosensationmaybe responsible for the changes observed in space microgravity. Overall, we are beginning to establisha role for mechanosensory-related signals in microgravity that can have an influence in maintainingneuromuscular health during spaceflight.

Keywords: Spaceflight; microgravity; C. elegans; Neuron; Development; mechanosensation

AMS962 **Responses of Bacterial Pathogens to Microgravity Environments: From Antibiotic Sensitivity to Virulence**

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As mankind moves toward permanently inhabiting outer space, alternatives to antibiotics that effectivelycontrol drug-resistant pathogens and a deeper understanding of the physiological changes theyexperience within microgravity environments are needed. The first part of my talk will focus on workbeing done in our lab to identify antibiotics that are effective against priority pathogens undermicrogravity conditions. For these studies, clinical isolates of antibiotic resistant E. coli, Klebsiellapneumoniae and Acinetobacter baumannii were used, each bearing a gene, i.e., mcr-1, blaKPC-2 andblaOXA-51, conferring resistance to carbapenem or colistin, two last-resort antibiotics. The antibiotic ofchoice in these experiments is another bacterium, Bdellovibriobacteriovorus HD100, a bacterium thatlives by predating on other Gram-negative bacterial species. The activity of this predator against thesepathogens was comparable to or better in simulated microgravity (SMG) as in normal gravity (NG),reducing the viabilities of these three pathogens by as much as 7-log in 24 h and hydrolyzing theirantibiotic-resistant gene pools by 97.4 to 99.3%. Subsequently, I will discuss how the physiologies of pathogens may shift under microgravity conditions.Using Staphylococcus aureus, we found this pathogen significantly alters its membrane composition,increasing the total percentage of anteiso lipids. As this shift increases the membrane fluidity, this wasexploited to demonstrate membrane-disrupting antibiotics and chemicals, e.g., daptomycin, SDS andviolacein, are all more potent under simulated microgravity conditions, i.e., killing efficiencies wereenhanced by as much as 23-fold. While these results highlight a beneficial physiological change inducedunder microgravity conditions, work with a different pathogen, Enterobacter hormaechei, found theopposite to be true as this microbe became more virulent under microgravity conditions. In collaborationwith Dr. Jin Lee, my group is currently exploring this. Dr. Lee's talk will discuss E. hormaechei'senhanced virulence from the perspective of the host organism (Caenorhabditis elegans) while minediscuss this finding from the perspective of the microbe.

Keywords: Microgravity; Pathogenic bacteria; Carbapenem; Colistin; *Bdellovibriobacteriovorus;Staphylococcus aureus*; *Enterobacter hormaechei*

Venue :Auditorium

Session 2A: Heat and Fluid Physics-1

Dec-03

AMS201

Research Progress on Condensation Enhancement Experiment in China's Space Station

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Condensation phase transition processes are prevalent in a variety of settings in space science and technology, such as space fluid management, life support systems, spacecraft cooling, and spacecraftthermal control. Gas-liquid two-phase heat transfer systems have better isothermal properties thansingle-phase systems and can realize high energy transport with small system mass and small loop flowrate, which has a good application prospect in aerospace field. “Condensation enhancement experimentmodule” developed on the basis of the research on ground condensation experimental bench, fallingtower experimental bench and numerical simulation. Utilizing the long-time stable microgravityenvironment of the space station and relying on the "two-phase system experiment cabinet" of theMengtian Space Module, the experiment on the enhancement of filmwise condensation heat transfer ofthe low surface tension workpiece in a long-time microgravity environment has been carried out. Thecharacteristics of the whole process of liquid film generation, climbing and spreading in microgravityenvironment are obtained by the visualization platform. It is found that the local minimum of liquid film thickness exists in the conjugate region of condensation liquid film and at the bottom of the fin, whichis different from the thickest liquid film at the bottom under gravity environment, which fills the gap inthe study of liquid film non-stability on the surface of single-pin fin structure under the long-termmicrogravity environment. The influence of surface microstructure, subcooling degree and otherparameters on the enhancement of condensation heat transfer performance is investigated, and themethod to enhance the condensation heat transfer performance for the low surface tension workpieceunder the long-time microgravity environment is proposed. The results can further improve the relevantscientific theoretical system of space condensation process, provide theoretical support for the spacephase change thermal system, and provide scientific and technological support for the wide applicationof spacecraft two-phase change thermal management system.

Keywords:microgravity ; phase change heat transfer; filmwise condensation; Space experiment.

AMS948 **Modelling side wall damping in confined Faraday instability systems**

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The manifestation of interfacial patterns, when two fluids with dissimilar but stably stratified densitiesare vibrated in the direction perpendicular to their common interface, is known as the Faradayinstability. The patterns vary from well-ordered structures to chaos and encompass both sub-critical aswell as super-critical modes of instabilities. Apart from the fundamental interest in understandingpattern formation, the Faraday instability finds its relevance in all space-based fluidic applications sinceall such systems are subjected to periodic gravitational fluctuations via g-jitter. For immiscible fluidsystems, the Faraday patterns depend on factors like system size, gravity, and interfacial tension thatmake up the system's natural frequency. Of these parameters, the present work focuses on understandingthe influence of side walls in confined systems. One may note that the theoretical analysis that usuallyassumes laterally unconfined walls agrees well with the experiments if the imposed parametricexcitation frequency is large or the side walls are sufficiently separated. At low frequencies, however,the modes occur as discrete bands, and the wavelengths typically become comparable to the cell size.

The patterns, i.e., modes seen at the onset of instability, reflect the influence of side wall geometrywherein the meniscus waves dominate. Consequently, a notable mismatch exists between theexperimental data and the prevalent theoretical results unless the experimentally measured dampinginformation is somehow fed back into the model. The biggest impediment in this regard, i.e.,characterizing the influence of contact line dynamics and the sloshing meniscus waves, is the lack of asimple theoretical model to represent the underlying physics. To overcome this issue, the current workproposes to use a slip-length model that allows for non-zero velocities at the side walls.

The extent ofthe slippage is managed here by the parameter called slip length, S. Since this parameter is generallyunknownapriori, we first experimentally determine the damping rate of small perturbations in the two-layer system. Then, in the theoretical framework, we adjust the slip length to match the resultingdamping to the experimentally measured value. Note that a proper approximation for the velocityprofiles must be chosen to obtain a closed-form solution for the theoretical damping rate. With the sliplength thus obtained from matching theoretical and experimental damping values, we reformulate theFaraday instability problem in three dimensions to estimate the critical amplitude and compare it withthe experimental data.

AMS250 **Utility of Lubricant Infused Surfaces for Enhancing Droplet Removal in Microgravity Applications**

Tonmoy Sharma[1]*, Rajnish Azad[1], Snehasis Daschakraborty[2], Rishi Raj[1]

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Droplet mobility and shedding of the impinging droplets effecting applications such as anti-icing, self-cleaning, condensation, among others, is primarily dependent upon the surface tension driven flows in microgravity conditions. Here, the droplet growth is high ($V \sim g^{-3/2}$) and shedding is governed by thetime scales of capillary oscillations [$\tau C \sim (\rho l V/\sigma)^2$] and viscosity oscillations [$\tau v \sim V^{2/3}/\upsilon$] wherein ρl, V, υ, σ and g are liquid density, volume, kinematic viscosity, surface tension and acceleration due togravity respectively. Lubricant infused surfaces impart gravity independent surface-tension drivenflows as compared to low energy coated surfaces which possess the potential of quicker coalescenceinduced droplet growth−larger oscillation−quicker shedding in microgravity applications. However,the frequent maintenance of these surfaces subjected to lubricant drainage renders it inapplicable tilldate for droplet removal applications in microgravity.

In this study, we discuss a new strategy of continuously replenishing the lubricant layer of LISover bare metallic surfaces by supplying lubricants from the vapor phase. We select an aroma molecule,linalool, which is an immiscible volatile surfactant exhibiting anti-corrosion characteristics. Linaloolreduces the surface tension of water droplets and its lower viscosity compared to traditional lubricants will reduce the shear drag. Accordingly, the increased capillary oscillations of the droplet in addition tothe viscous oscillation of the lubricant film will result in quicker droplet shedding at lower volumes.

Experimentally we verify that liquid linalool infuses on bare copper surfaces and does not cloakthe impinging water droplets. We then perform molecular dynamics simulations and verify that linalool molecules in vapor phase eventually diffuse to the solid-water interface of a surface pinned dropletthrough the contact line and develop into stable LIS. Finally, we demonstrate surface-tension driven high water droplet mobility on bare copper surfaces during simultaneous condensation of linalool andwater vapors. We believe that our experimental evidence with molecular-level understanding will helpplan suitable controlled experiments and realize high droplet removal and shedding using LIS inmicrogravity applications.

Keywords: Lubricant infused surface; Aroma molecules; Droplet removal; Microgravity.

AMS264 **Enhancing Boiling Performance in Adverse Gravity Conditions with Imidazolium-Based Ionic Liquid Additives**

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Boiling is fundamentally a two-phase heat transfer process that utilizes the latent heat of vaporization. Thephase change processes, such as boiling and condensation, transfer heat with minimal change in surface temperature. Hence, the irreversibility associated with such processes is lesser in comparison to single-phase heat transfer processes such as conduction and convection (that exhibit higher changes in surfacetemperature). Due to low irreversibility and high heat transfer ability, boiling is utilized in variousapplications ranging from household applications, electronic cooling, refrigeration and air-conditioning,power industries, and space and rocket industries, among others. Specifically, the boiling heat transfercoefficient (HTC) dictates the irreversibility of the system and the critical heat flux (CHF) decides the maximum heat transfer limit. The benefits of high HTC and CHF during boiling are diminished if theebullition cycle—comprising bubble nucleation, growth, departure, and subsequent rewetting of theheated surface—is disrupted. As a result, heat transfer during boiling in microgravity or adverse gravityconditions is significantly reduced, as the ebullition cycle is absent or hindered due to the lack ofbuoyancy or opposing buoyant forces. Accordingly, various approaches have been attempted in the pastto enhance both the performance parameters during boiling in space or microgravity conditions; however,most of them are energy intensive. Hence, a facile working fluid modification technique has recently beenexplored to demonstrate nearly 3 – 4 times higher CHF and HTC than the baseline case in adverse gravity boiling experiments. Specifically, boiling with the aqueous solution of surfactants and surface-active ionicliquids (SAILs) leads to the formation of multiple non-coalescing small bubbles with significantly largewet areas on the heater surface. The force of repulsion due to the interaction of additive monomers adsorbedat the liquid-vapor interface of neighboring bubbles induces a completely passive bubble departure awayfrom the inverted heater surface (adverse gravity condition) against the combined effect of buoyancy andsurface tension. The fluid's ability to form non-coalescing smaller bubbles, characterized by its foamability,was found to be a critical factor in boiling performance, as demonstrated in studies of various surfactantsand SAILs under adverse gravity boiling conditions. Conversely, it is well-established that improvedwettability of the heater surface can also enhance boiling performance. In this work, we explore additivesthat simultaneously enhance the solution's

foamability and improve the surface wettability. Specifically,we utilize imidazolium-based ionic liquids as additives to leverage the combined effects of foamability andwettability for improved boiling performance under adverse gravity conditions. With these chosenadditives, we were able to analyze and discuss the individual contributions of foamability, wettability, andtheir combined influence on boiling performance. Overall, we believe that fluid modification is a simple,robust, and scalable technique for enhancing boiling performance, particularly in microgravity or spaceapplications. Moreover, this technique holds immense potential due to the wide variety of these solubleionic liquids.

Keywords: Boiling; Bubbles; Ionic Liquids; Critical Heat Flux; Heat Transfer Coefficient.

AMS316 **Design of thermal passive control system for rotating elements of Micro Dual Gimbal Antenna (DGA) deployed on small LEO satellite**

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This paper presents a comprehensive thermal design and analysis for the drive assemblies of aminiaturised Dual Gimbal Antenna (DGA) system deployed on a small satellite. The DGA enablesprecise pointing and tracking capabilities crucial for communication and earth observation missions.The configuration of DGA consists of two drive assemblies, pitch drive module (DM1) and roll drivemodule 2 (DM2). DM1 rotate from +105° to -105° from +pitch to -pitch about the +yaw axis.Similarly, DM2 rotate from +105° to -105° from +roll to -roll about the +yaw axis. In space therotating elements of the DGA are subjected to extreme thermal conditions, necessitating robustthermal management strategies. Thermal management is critical to ensure the operational integrity,reliability and longevity of the rotating components which are subjected to varying environmentalconditions in space. This rotational capability exposes different parts of the drive assemblies tovarying external thermal loads mainly from the Sun and Earth, posing significant thermal managementchallenges.In this study Micro-DGA (M-DGA) was mounted on small spacecraft which is a 3-axis stabilized,sun-oriented satellite in the Low Earth Orbit (LEO) (475 km) with 37° inclination and varyingequatorial crossing time. In LEO orbit the proximity to Earth results in a notable planetary IR load that must be carefully managed in the satellite's thermal design. The M-DGA is mounted on a structuralbracket on panel perpendicular to bottom deck. Designing thermal management systems for M-DGApresents significant challenges primarily due to two key factors. Firstly, the internal dissipation of thedrive motors varies from 4W to 8W as a function of temperature. During operation, dissipation ofdrive motor increases with rising temperature. Secondly, the rotational nature of both drives duringdata downloads operation resulting in dynamic orientation of the drive modules. Additionally, theDGA must withstand external environmental loads this complicates the thermal control system design.Due to varying loads experienced at different positions, a thorough thermal analysis was carried out todetermine worst- case thermal scenario for each drive individually.The drive assemblies are specified to operate within an acceptance temperature range of -10 °C to 50°C. During operational condition, the drive motor is designed to withstand temperature up to 130 °C.The study encompasses detailed thermal mathematical modelling, including thermal analysis atdifferent orientations to identify worst-case for each drive and simulations to evaluate the thermalresponse of critical components under operational conditions. Based on worst-hot case scenarioresults, the design incorporates Optical solar reflector (OSR) on the drive motor and the front plate ofboth DM housings, while other locations are insulated using Multi-layer insulation (MLI). Heaterpower is designed to maintain both drive assemblies with in specified temperature limits under theworst cold-case scenario. The design is experimentally validated through a thermal balance test. Theoutcomes successfully validate the thermal design and contribute to the thermal resilience and operational efficiency of M-DGA under harsh environmental conditions.

Keywords: Drive module, Temperature, Dual Gimbal Antenna (DGA), Low earth orbit (LEO).

AMS426 **Understanding and Optimizing the Surface Activity of Ethanol-Water Mixtures for Microgravity Applications**

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Ethanol has emerged as a crucial test fluid in thermal management systems, especially as a self-rewettingfluid in thermosyphons for microgravity applications. In microgravity, the absence of conventional buoyancy-driven transport mechanisms poses challenges for effective thermal management. Ethanol'ssurface activity is vital for consistent rewetting of evaporator surfaces. Despite extensive research, theprecise ethanol concentration range that optimizes surface tension gradient driven flows and hence itsself-rewetting property in microgravity remains a topic of considerable debate among researchers. Ourexperiments on foamability, and film stability conducted by dropping ethanol onto pools of ethanol-water mixtures of various concentrations, show that ethanol's surface-active characteristics arenoticeable only at concentrations up to 10 % molar in water. All-atom molecular dynamics simulationfurther demonstrated that surface tension and other interfacial properties are predominantly influencedat ethanol molar concentrations between 0-10 % in water. This finding aligns with free energy analyses,suggesting that the stabilization energy of an ethanol molecule at the interface is similar to that in thebulk solution when the ethanol concentration is above ~7%. Ethanol begins to act less like a surfaceagent and more like a homogeneous solution when its molar concentration in water surpasses 10%. This transition is attributed to changes in the number and strength of ethanol-water hydrogen bonds and marksthe point where ethanol's self-rewetting efficiency in microgravity may diminish. These results highlightthe importance of defining the optimal concentration range for ethanol's self-rewetting properties. Ourthermosyphon experiments at different molar concentrations demonstrate the role of the surface-activenature of ethanol-water mixtures in self-rewetting phenomena. This work emphasizes the need toidentify the concentration range at which ethanol effectively acts as a surface-active molecule andcontributes as a self-rewetting agent, ensuring its optimal application in thermosyphon systems for spacemissions.

Keywords: Ethanol-Water Mixture; Evaporation; Surface activity; Self-rewetting; Thermosyphon;Microgravity.

Venue :Auditorium

Session 3A: Life Science and Biotechnology-2

Dec-03

AMS379

Life Science Experiment Facilities on the Chinese Space Station

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The Chinese Space Station has provided unprecedented experimental conditions for life science in spacefor China. As the space station transitions from the construction phase to the operational phase, the fieldof Chinese space life science has entered a period of rapid development. The space station, serving asa national space laboratory, offers more advanced experimental equipment, more abundantexperimental resources, more frequent experimental opportunities, and more flexible modes ofexperimental operation. The long-term presence of astronauts is indispensable for the smooth conductof experiments, such as the installation, transfer, low-temperature freezing, and return of experimentalsamples.The Chinese Space Station has established two space biology experimental platforms: the Life Ecological Experiment Cabinet and the Biotechnology Experiment Cabinet. The Life EcologicalExperiment Cabinet is a microgravity science experimental platform that takes individual organismssuch as plants, fish, snails, fruit flies, and nematodes as research objects. It includes general biologicalculture modules, small general biological culture modules, small centrifuge modules, small controlledlife ecological experiment modules, microbial detection experiment modules, and cabin radiationenvironment measurement modules. The Biotechnology Experiment Cabinet focuses on biologicalsamples at the cellular and tissue levels, including biotechnology experiment modules, proteincrystallization analysis modules, cell and tissue detection and control modules, and specialized experiment modules. This article reviews the development history of Chinese space life science experiments in the pastdecade, focusing on the life ecology and biotechnology scientific experimental systems on the ChineseSpace Station, and briefly introduces the space life science experiments that have been carried out onthe Chinese Space Station.

Keywords: Space Life Science, Space Biology, Life Ecology, Biotechnology.

AMS740 **μBioSat: A platform for microbial analysis in space**

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Understanding the impact of microgravity conditions on biological activity is critical to fullycomprehending long term effects on humans. In this context, microbes have garnered significantattention since they serve as model systems that can be quickly used to study specific biologicalprocesses. Incorporating such experiments in a modular Lab-on-Chip (LoC) paradigm has gainedsignificant importance in small satellite developments, facilitating the advancement of science in space.

Here, we develop a payload designed to perform microgravity experiments on bacterial cultures andstudy changes in biological activity, all within an independent pico-satellite. The current setup incubatesthreemillifluidic wells to conduct independent microbiological experiments, which helps us establishstatistical significance and in-built redundancy in case of failure. The configuration of wells has twoindependent experiments and one control well, to determine the reference. These wells areindependently regulated and controlled by a fluidic delivery system consisting of a network of valves,pumps, and reservoirs to ensure that the experiment can be carried out without human intervention. Oursetup provides a robust method to measure bacterial growth using optical density values. Wedemonstrate this by using LED-photodiode pairs, latched on to each of the three wells, whichcontinuously monitor the state of the biological species inside the wells. We use this system to study the growth pattern of Sporosarcinapasteurii, a spore-forming bacteria widely explored for its capability toinduce calcite precipitation.

The payload’s on-board microcontroller controls the logical flow of the experiment and establishescommunication with external systems for active telemetric control. We also demonstrate the flightcapabilities and launch compatibility of the payload with ISRO's Satellite Launch Vehicle (SLV) series,by subjecting the qualification model to random vibration analysis and harmonic analysis. Theseanalyses validate the structural integrity of the current design and its technology readiness level. Thispayload represents a complete solution for growing and querying specific microbial species to studytheir properties under microgravity conditions. Our approach to microfluidic control within a pico-satellite facilitates the precise regulation of experimental conditions without human intervention, a firstin this scale of satellite experimentation. This work contributes to the development of autonomous,biological and

medical research platforms in space, with implications for both fundamental science andthe advancement of space biosciences which can be accessible for researchers at a lower cost.

Keyword: Lab-on-Chip, Millifluidic, Microbiological, Microgravity, Payload, Bacterial growth, MICP(Microbially induced calcite precipitation), Sporosarcinapasteurii, Random vibration analysis,Harmonic Analysis, Pico-satellite.

AMS805 **Eggshell Membrane as potential preventive medicine for pulmonary fibrosis**

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Fibrosis is a disease that harms the extracellular environment and can invade all organs, accountingfor 45% of deaths in developed countries. ISS mission's omics data shows that fibrosis signals areenriched in the lungs, kidneys, skin, and liver, and that prevention is necessary for deep space flight.Fibrotic lung disease is characterized by interstitial remodeling, destruction of the tissue structure,irreversible scarring, and decreased lung function. Organ stiffness is regulated by the extracellularmatrix (ECM) secreted from cells. Since downregulation of type I collagen (COL1) is key toinhibiting fibrosis, it is important to regulate transforming growth factor-β (TGF-β) as an upstreamchemical signal. Aging is a high-risk factor for obstructive and fibrotic lung diseases. Fibrotic lungdisease leading to decreased lung function is characterized by interstitial remodeling and tissuescarring (sclerosis), with destruction of alveoli and excess deposition of COL1, an ECM componentsecreted by fibroblasts. Therefore, regulating TGF-β as a profibrotic signal is essential to suppresspulmonary fibrosis. In pulmonary fibrosis, TGF-βsignalling is mediated by Smad and YAP/TAZ, andTAZ linked to the pathology of pulmonary function is observed in lung fibroblasts from patients withidiopathic pulmonary fibrosis. Although fibrosis is thought to be irreversible, it is an interventional condition. Decorin (DCN) blocks TGF-β signaling in pulmonary fibrosis, although there are nocellular pharmacological methods to stimulate DCN secretion. We previously showed that chickeneggshell membrane (ESM, a well-known wound-healing material) promotes dcn gene expression infibroblasts. In this study, we investigated whether ESM stimulates DCN secretion as an endogenousmediator and ameliorates pulmonary fibrosis. Decorin secretion was significantly enhanced in the WI-38 lung fibroblast culture supernatants supplemented with ESM. This effect was increased with majorcomponent lysozyme and maximally promoted in experiments with lysozyme and ovotransferrin (thetwo main proteins in soluble ESM) at a 16:1 concentration ratio, the ratio in the ESM extract. DCNsecretion by ESM modulates TGF-β signaling in lung fibroblasts by reducing TAZ and

pSmad2nuclear localization. Decorin siRNA experiments confirmed that nuclear localization of TAZ is DCN-dependent. In a mouse model of bleomycin-induced pulmonary fibrosis, all fibrotic markers of ESMtreatment group such as hydroxyproline, and both evaluation of fibrosis density by automatedthresholding of picrosirius red-stained lung tissue scan images and Ashcroft fibrosis scores, and alsothe nuclear localization of TAZ were reduced after 2 weeks compared with control group. Recently, we reported that oral supplementation with ESM for 8 weeks in healthy subjects significantlyincreased respiratory function (forced expiratory volume in 1 s to forced vital capacity ratio[FEV1/FVC]) compared to that in controls1), furthermore, long-term (22 week) ESM consumption byhealthy individuals significantly improved vital capacity and FEV1/FVC. This study2) reveals thatESM, a well-established wound-healing material, may be a potential preventive medicine forpulmonary fibrosis. 1)Ohto-Fujita, et al., Journal of Fiber Science and Technology, 77 (2021), 258-65. 2)Ohto-Fujita, et al., Biochemistry and Biophysics Reports, 39 (2024/09/01/ 2024), 101806.

Keywords: decorin, eggshell membrane, lysozyme, ovotransferrin, pulmonary fibrosis

AMS921 Exploration of Biomaterials for Preventing Muscle Atrophy with Space Experiment

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Long-term stay in space causes muscle atrophy, one of the hurdles preventing long-term spaceexploration, like a mission to Mars. We studied two novel reagents, Cbl-b inhibitory peptide (Cblin)and celastrol, a quinone methide triterpene, in preventing muscle atrophy. Cblin is an inhibitor of Cbl-b, which is muscle atrophy-associated ubiquitin ligase, and has been reported to play an essential rolein unloading muscle atrophy caused by spaceflight. Celastrol is reported to alleviate muscle atrophyby modulating the expression of heat shock proteins. The experimental module was sent to theInternational Space Station (ISS) as a Myolab space experiment project (PI: Takeshi Nikawa) toexamine the function of Cblin and celastrol in space. Rat L6 muscle cells were incubated in space toinduce muscle atrophy under microgravity and treated with Cblin and celastrol. We demonstrated themodulation of muscle atrophy-related genes by RNA-seq analysis, and the implication of theexperiments will be discussed.

Keywords: Microgravity, Cblin, Celastrol, Space experiment, Muscle atrophy

AMS934 **Impact of seed exposure to simulated microgravity on growth and development in tomato (Solanum Lycopersicon L.)**

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Gravity is the sole unchanging basic force that has persisted throughout the Earth's existence.Microgravity is a feature of the space environment that causes a change in gravity. This changinggravity puts stress on the metabolism, growth, and development of organisms and plants.Microgravity is a unique environment that generates physical and physiological changes in plants, anda full understanding of plant growth and development under microgravity is essential for spaceagriculture. Recent research has shown the impact of microgravity on plant growth and developmentalong with alteration in plant morphology and physiology. In the present study, we explored thepotential of microgravity as an innovative tool to induce specific phenotypes for terrestrial cropimprovement applications. Tomato seeds of the Anagha variety were subjected to simulatedmicrogravity treatments and evaluated for various parameters, including seed germination, seedlingvigour, physiological responses, biochemical characteristics, and overall plant growth in bothlaboratory and open field conditions. A random positioning machine (RPM) was employed tosimulate microgravity of the order of 10-3g. The seeds were carefully placed in sample tubes andarranged inside a sample holder with controlled temperature and humidity. The treatments includedvarying durations of microgravity exposure (4 hours – 24 hours) of the seeds where the RPM wasrotated at slow speeds (25-40rpm).

The study revealed that under the employed environmentalconditions, the simulated microgravity treatments significantly enhanced germination percentage,seedlingvigour, and speed of germination, while also promoting early flowering. Enhanced pollenviability under simulated microgravity resulted in increased number of fruits per plant, average fruitweight, and total yield per plant. Additionally, we observed a rise in total chlorophyll content and cellmembrane stability across different treatments, alongside improved root characteristics such as rootlength, root volume, and root biomass, which contributed to enhanced plant height and overallbiomass. While the end product of lipid peroxidation, malondialdehyde

content increased, it wascounterbalanced by elevated levels of peroxidase, superoxide dismutase, lycopene, and ascorbic acidunder simulated microgravity. Conversely, total sugar and anthocyanin pigment levels decreased.Collectively, this study elucidates the efficacy of simulated microgravity as a pioneering tool forenhancing consistent root and shoot phenotypes, which could be strategically exploited to enhancetomato varieties for improved growth and development in both terrestrial and extraterrestrialagricultural systems.

Keywords: Microgravity, Clinostat, Antioxidants, Seed germination.

Venue: Hall-03

Session 1B: Combustion-1

Dec-03

AMS082 **Development of Experimental Payload for Studying Turbulent Transition of Non-Premixed Jet Flames under Microgravity**

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Non-premixed combustion is the primary combustion method in aerospace propulsion, playing acrucial role in energy, environmental impact, and aerospace propulsion. The study of turbulenttransition mechanisms and flame structure evolution of non-premixed jet flames in microgravity isimportant for achieving efficient, low-emission combustion. Study on turbulent transition and flamestructure of non-premixed jet flames in microgravity is one of the space experiment projects in thecombustion science experimental rack of China's space station. For this project's space experimentrequirements, a burner experimental payload was developed, and the development process of thispayload was reported. The burner uses a round tube jet flame configuration, with fuel or fuel-diluentmixtures injected from the nozzle center into a stagnant environment filled with an oxidizer. The studyinvestigates the turbulent transition characteristics and patterns under different nozzle diameters anddifferent fuel-to-diluent ratios. During the burner development process, initial research was conductedon the extinction characteristics of jet flames with different fuels in nozzles of varying diameters, determining the blow-off characteristics for different fuels. The study also examined the turbulenttransition characteristics of flames with different fuel and diluent ratios in various nozzles, sequentially determining the fuel type and nozzle size for space experiments. The designed burner completed ground environment experiments and matching experiments, including gas release andmicrobial experiments, and underwent a medical suitability analysis. Matching experiments wereconducted in a ground-based mirror cabinet to verify the compatibility of the burner with themechanical and electrical interfaces of the combustion science experimental rack's mirror rack. Theimpact of igniter height on ignition characteristics was studied, and the combustion rack's diagnosticsystem was used to study flame imaging characteristics. Flame imaging was achieved, and the resultswere analyzed to meet the requirements for space combustion experiments. Environmental and groundexperimental results indicate that the developed

burner meets all technical specifications and canfulfill the needs of turbulent transition experiments for non-premixed jet flames in the space station.

Keywords: Micogravity; Non-premixed combustion ; Jet flame; Turbulent transition; experimental
payload.

AMS092 **Extinguishing Gas Jet Flame Experiments Aboard the Chinese Space Station**

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Combustion phenomena in a microgravity environment differ significantly from those in the Earthnormal gravity environment. Microgravity combustion experiments allow for more fundamentalinvestigations in advanced combustion issues. The Chinese Space Station (CSS) is designed to supportin-orbit combustion science experiments with multiple fuel types including gaseous, liquid, and solidfuels. The first series of CSS combustion experiments are gaseous combustion experiments, some ofwhich have been conducted in the Combustion Science Rack (CSR). The article presents the types ofscientific research that can potentially be supported by the Combustion Science Application System(CSAS) and the Gaseous Combustion Experiment Insert (GCEI) in the CSR, as well as a first set ofexperiments on microgravity jet flames .

The CSAS provides the GCEI with necessary resources such as cooling water, power, and inlet gas. TheGCEI supports gas flow control, allowing adjustment of gas type, flow rate, and ignition energy to beadjusted according to the scientific requirements. Different replaceable burners can be installed byastronauts in the GCEI to study behaviors of various forms of flames. . The CSR optical diagnosticssubsystem can provide data on flame dynamics, flow field, and spatial distribution of OH and CH. TheGCEI automatically performs a series of operations, including configuring the combustion environmentgas, ejecting fuel gas, hot-wire ignition, recording experimental parameters, performing opticaldiagnostics, filtering and recirculating, and exhausting waste gases. The flow rates of fuel, oxidizer, andinert gas are controlled by mass flow controllers and gas distribution solenoid valves. The GCEI caneffectively realize the in-orbit microgravity gaseous flame experiments and provide support and designbasis for subsequent versatile projects.Both in-orbit experiments and numerical simulations are used to analyze the transient dynamics ofextinguishing jet flames in microgravity. The results suggest that the jet flame exhibits a “ring-like”structure with partially premixed hooks at its edges prior to a global extinction. The extinction isassociated with strain rate and radiation effects as analyzed by numerical simulation and comparisonwith the experimental results. The overall non-premixed jet flame exhibits a reduced range ofequivalence ratios with two edges retracting in a premixed manner under the considerable influence ofradiative heat loss. The contribution of strain and radiation effects on local extinction is demonstratedby normalized flame strain rate, radiative heat loss, and local Damköhler number. The results suggestedthat radiative heat loss for the edges of non-premixed region can occupy 40% of the local heat release.A diminishing influence of the strain rate effect on flame propagation leads to a shift towards radiation-driven extinction.

Keywords: Chinese Space Station; Combustion Experiment Insert; Combustion Science Rack; flameextinction; jet flame.

AMS164 **Bayesian MCMC estimation of the limiting oxygen concentrations for B-LDPE tubes across various gravity levels**

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Accurately predicting the flammability limits of solid materials in varying gravity environments iscrucial for ensuring fire safety in manned space missions, yet it remains a significant challenge. Thisstudy introduces an effective approach for predicting the limiting oxygen concentration (LOC) ofmaterials in low-gravity environments by integrating physical modelling of flame spread with machinelearning and ground-based experimental data. A flame spread scaling model was developed based onthe energy conservation equation, accounting for heat supply from both gas and solid phases, surfacere-radiation, and gas-phase radiative heat loss. Model parameters were estimated using a Bayesianapproach, specifically the Metropolis-Hasting (Markov Chain Monte Carlo) method, trained onexperimental data of the LOC of B-LDPE tubes under different hypergravity and opposed flow conditions. The model successfully predicted the LOC curve for the sample under low gravity andprovided safety margins based on parameter uncertainty. Additionally, the model facilitated calculationsof energy transport processes at the extinction limit. Results indicate that while the scaling model is anonlinear function of flame spread rate, flame spread under LOC conditions exhibits a single stablesolution, with solid-phase heat conduction as the primary driving force. Notably, across different gravity conditions, the minimum LOC (MLOC) remains largely unchanged despite the presence of distinctquenching and blowoff branches. These findings offer valuable insights for screening aerospacematerials using ground-based facilities.

Keywords: Limiting oxygen concentration; Gravity effect; Markov Chain Monte Carlo; Solid material;Fire safety.

AMS598 **Effect of oxygen concentration, pressure, and opposed flow velocity on the flame spread along thin PMMA sheets: Experiments and Numerical modelling**

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Fire safety is one of the major concerns in human space exploration. With the possibility of a futurespacecraft environment maintained at low pressure and high oxygen concentration, to reduceextravehicular activity timing and structural load, it is important to study fire safety aspects in theseenvironmental conditions. Flame spread is a classical problem studied to obtain insights on fire safety.In recent microgravity drop tower experiments by Ries et al. [1] on opposed flow flame spread rate (v_f)along thin PMMA sheets in various atmospheric conditions of pressure, p (60 kpa-101.3 kpa), molaroxygen concentration, X_{O2} (21%-35.4%) and opposed flow velocity, U (60 mm/s-200 mm/s), the flamespread rate was found to vary as $v_f \sim (X_{O2})^2 p^{0.3} U^{0.15}$. The higher dependence of flame spread rate on theoxygen concentration than the ambient pressure makes these atmospheric conditions higher fire risk onboard spacecraft. In this work, a detailed 3D in-house numerical flame spread model of a thin PMMAis developed to simulate flame spread process under various conditions of pressure, oxygenconcentration and opposed flow velocity. The model comprises unsteady governing equations ofcontinuity, momentum (Navier-Stokes) and energy in the gas phase, and equations of mass conservationand energy in the solid phase. The gas phase and solid phase are coupled through the boundaryconditions. The reaction in the gas phase is modelled as a one-step global reaction, and in the solidphase, zeroth-order solid fuel pyrolysis is assumed. Radiation in the gas phase is modelled using theDiscrete Ordinate Method. The computed flame spread rates in microgravity and their respective fuelsurface temperatures have a good match with the ZARM drop tower tests. Since the flame spread rateis proportional to the net heat transfer rate to the solid fuel ahead of the flame in the preheat region, theheat transfer mechanisms in various atmospheric conditions is also discussed.

Keywords: Microgravity; Flame spread rate; Oxygen concentration; Pressure; Opposed flow velocity

AMS290 **Effect of insulation thickness on the overload ignition of electrical wires in normal and microgravity**

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Aerospace vehicles are densely populated with electrical wires, which increases the fire risk caused byshort circuits or overloads. During the overload ignition, the heat and mass transfer are significantlyinfluenced by insulation materials and environmental factors. This work investigated the effects ofinsulation thickness and gravity level on the overload ignition of electrical wires with 45-A current.Low-density polyethylene (LDPE) insulated NiCr wires with insulation thicknesses varying from 0.15to 0.6 mm and an inner core diameter of 0.8 mm were tested by a 3.6 s drop tower. The effective testinglength of the sealed wire sample was fixed at 18 mm due to the limited space within the drop capsule.Results demonstrate that the ignition delay time of overloaded wires monotonically increases asinsulation thickness increases or gravity level decreases. An extremely hazardous situation was identified where ignition occurs even though the metal core fuses prior to ignition due to the excessiveoverheating time for wires with thicker insulation. Two ignition modes were summarized: “spontaneousignition mode” that the ignition location is commonly at the periphery of the pyrolysis gas cloud awayfrom the high-temperature core, and “core-forced ignition mode” that the initial flame spot originatesfrom the exposed high-temperature core.

The former occurs in both microgravity and normal gravity forwires with thicker insulation, while the latter occurs in normal gravity with thinner insulation. Thesetendencies were interpreted based on the motions of pyrolysis gas and deformation of insulating layerprior to ignition, as well as 3-D simulations for specific cases. As the metal core overheats, the insulatinglayer softens and pyrolyzes, and then detaches in normal gravity or shrinks in microgravity, exposingthe red-hot inner core. The release of pyrolysis gases is delayed longer for wires with thicker insulation.The mixing process of pyrolysis gases and air is weakened in microgravity due to the absence of naturalconvection. After ignition, the flame in microgravity is nearly cylindrical, but it is heavily stretched innormal gravity. This study helps to understand the mechanisms and modes of wire overload ignition,providing references for spacecraft fire safety.

Keywords: Overload ignition; Electrical wire fire; Insulation thickness; Microgravity.

AMS296 **A numerical modelling of flame spread over insulated electrical wire**

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A 2D/axisymmetric model of opposed-flow flame spread over insulated electrical wire has beendeveloped and solved numerically. The gas-phase combustion model includes the full Navier-Stokesmomentum equations along with conservation equations of mass, energy, and species. The solid phasemodel consists of continuity and energy equations whose solution provides boundary conditions for thegas phase. In this study, two samples with inner core of nichrome and copper were considered. The innercore has a diameter of 0.5 mm, and the insulation thickness is 0.15 mm. It is observed that flame spreadrate is higher for the sample with higher thermal conductivity of core in both normal and microgravityenvironments. Copper has a thermal conductivity of 8.9×10^{-1}cal/cm-s-K while nichrome has a thermalconductivity of 3.58×10^{-2}cal/cm-s-K. The forward heat conduction through the metallic core enhancesthe preheating of the insulation hence a higher flame spread rate for the sample with core of higherthermal conductivity. The study is also carried out at different opposed flow velocities and oxygenconcentrations to investigate the effect on flame spread and extinction in both normal and microgravityenvironments.

Keywords: flame spread; electrical wire; thermal conductivity; modelling.

AMS125 **On Simulating non-premixed flames in microgravity by employing sub-atmospheric pressures**

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A complete understanding of the burning characteristics of non-premixed flames in microgravity is ofgreat importance for improving spacecraft fire safety. Due to the incidence of gravity on combustionprocesses, non-buoyant diffusion flame behaviour has considerable differences with buoyant diffusionflames on earth. Experimental tests in space, drop tower or parabolic flight are costly and difficult.Reducing buoyancy effects of diffusion flames by utilizing lower ambient pressures is one potential wayto simulate a spacecraft environment on earth, which is easier to be implemented. The intensity ofbuoyancy can be varied in sub-atmospheric pressures, and the characteristic residence time becomeslonger.In this work, burning characters of non-premixed flames on a 25 mm circular burner in a pressurechamber with different reduced ambient pressures were experimentally investigated. Methane was usedas fuel at very low injection velocity (mass flow rate) that can be controlled by a mass flow controller,and the diffusion flame is generated by the reaction of the gaseous fuel with air. Visualization of thespontaneous flame emission is made by video recording. Flame temperature and radiative heat flux weremeasured by thermocouples and a radiometer. The non-premixed flames characteristics including flameappearance and luminosity, flame length scales, axial temperature distribution and radiant output weresystematically measured and discussed at ambient pressures ranging from 20-100 kPa. Experimentalresults show that flame luminosity or intensity decreases as pressure is reduced. The length scale ofsoot-free (blue) flame zone becomes longer with the decreased pressures. And the flame base widthseems to increase, which can be attributed to the enhancement of mass diffusivity at lower pressure.This is similar to the phenomenon in microgravity. Flame flickering frequency decreases with thedecreasing ambient pressure. The cease of non-premixed flames flicker is observed until a relativelylow pressure, indicating the hydrodynamic instability caused by buoyancy effect is eliminated. Axialflame temperature is found to decline especially near the lower flame part at reduced pressures, whicharises from the dependence of mass and thermal transport processes on pressure. Finally, the similarityand differences of the non-premixed flame characteristics in sub-atmospheric pressures andmicrogravity are discussed. There exists similitude of flame geometry between the reduced pressuresand reduced gravity. However, the finite-rate chemical kinetics should be different in these twoconfigurations. For

instance, the recued pressure and microgravity has opposite effects on soot formationof non-premixed flames. This work could provide guidance for potential on-earth testing for fire safetydesign in spacecraft and space habitats.

Keywords: Non-premixed flames; Flame characteristics; Low pressure; Microgravity.

AMS390

Numerical Investigation of the Effect of Strain Rate on the Flammability of Hydrofluorocarbons

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To enhance the fire safety of manned space missions, it is crucial to elucidate the effect of gravity oncombustion phenomena. Previous studies [1][2] have experimentally investigated the influence ofambient gas flow velocity on the limiting oxygen concentrations (LOCs) for opposed flame spread overvarious solid materials, showing that the LOC of many materials decreases in microgravity, wherenatural convection induced by the flame is eliminated. The authors have also investigated the LOCs ofelectrical wires insulated with low-density polyethylene (LDPE) and ethylene-tetrafluoroethylene(ETFE) [2], discovering a significant decrease in the LOC of ETFE-insulated wires in microgravity. Incomparing the effects of ambient gas flow velocity on LOCs across different materials, the enhancedflammability of ETFE with decreasing ambient gas flow velocity is remarkably pronounced, suggestingthat the flame-retardant properties of halogens are particularly sensitive to changes in ambient gas flowvelocity.This study, therefore, aims to elucidate the underlying mechanisms responsible for the enhancedflammability of ETFE in microgravity by comparing the effects of strain rate on the flammability ofhydrofluorocarbons (HFCs) and hydrocarbon fuels (HCs). A numerical simulation of a one-dimensionalcounter-flow diffusion flame was performed to investigate the flame structure and extinction limits, withburner inlet velocity, fuel type, and oxygen concentration in the oxidizer as key variables.Difluoromethane (CH2F2) and methane (CH4), which possess similar molecular structures, were selectedas the fuels. A comparison of the calculated relationships between strain rate and extinction limits foreach gaseous fuel revealed that the flammability limit of CH2F2 is more sensitive to strain rate than thatof CH4. This finding aligns with the observed trend between LOC and gas flow velocity for LDPE-andETFE-insulated wires. At reduced strain rates, the flame structure of CH2F2 becomes thicker, with thelocations of active CH2F2 decomposition and peak HF formation shifting away from the position of theheat release rate (HRR) peak. This suggests that the increased flame thickness may contribute to theenhanced flammability of ETFE in microgravity.

[1]S. Takahashi, K. Terashima, M.A.F. bin Borhan, Y. Kobayashi, Relationship Between Blow-OffBehavior and Limiting Oxygen Concentration in Microgravity Environments of Flame RetardantMaterials, Fire Technol. 56 (1) (2020) 169–183.

[2]Y. Konno, M.Z. Bin Zainal, N. Hashimoto, O. Fujita, Application of ISO 4589-4 to determinelimiting oxygen concentrations for opposed-flow flame spread over thin electric wires and theircomparison with microgravity data, Fire Saf. J. 141 (2023) 103989.

Keywords: Space fire safety; Fluoropolymer; Hydrofluorocarbon; Limiting oxygen concentration;Counter-flow-diffusion flame; Stretch extinction

Venue: Hall-03

Session 2B: Construction & Manufacturing in space-1

Dec-03

AMS327 **Cold Atoms in Microgravity**

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Cold atoms are widely used in frequency standards, matter wave interferometry, gravimeters, quantuminformation and computation, and etc. Quantum properties of cold atoms are also deeply investigated,such as Bose-Einstein condensation, quantum degenerate Fermi gas.
The microgravity gives cold atoms a new opportunity. Cold atoms in microgravity have longerlifetime and thus has some different features from on ground. In this talk, we will summarize spacemissions organized by us. In September 2016, we launched the first cold atom clock (a mission calledCACES) into a spacecraft Tiangong-2, which had worked in orbit for 3 years until the Tiangong-2 leftfrom the orbit. This mission paved the way for space applications of cold atoms. We will also presentthe results on missions in China Space Station, CAPR and CAMiCS, which are missions on the ultra-cold atom physics and cold atom microwave clock respectively. We will also introduce our plannedmissions on cold atoms in future.

Keywords: Microgravity; Cold atom clock; Bose-Einstein condensation; Quantum effect of gravity.

AMS104 **Research on the role of microgravity and other extraterrestrial environments in reconstructing worldviews as an artistic activity**

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The recent research of life exploration in the solar system may challenge the uniqueness of Earth’s lifeand may also suggest the possibility that the life and cultural values coexist with the physical worldacross the universe. In this era, or at this stage of research, it is necessary for researchers in both scientificand artistic fields to collaborate in considering the transition from Earth civilization to Space civilization.

In our previous research, we have demonstrated that the new environments and worldviews acquiredthrough space exploration can provide a valuable foundation for new research and creative activities indaily life on Earth. This was also an attempt to reconsider the role of art, along with scientific knowledge,in achieving and maintaining a healthy and cultural life on Earth.

Specifically, we conducted workshops that sought to remove the limitation of "gravity (1.0G)", one ofthe typical foundations of conventional daily worldviews on Earth, to delve into the artistic andhumanistic essence of creative works. This relationship, where a “Microgravity environment” expandthe capability of creative activities, parallels the notion that “a perspective from space” encouragesliberation from a worldview based solely on Earth’s environment.Since the last AMS, we have focused on this relationship and been progressing with new creations inaddition to our previous workshops. These new creations depict the potential forms of extra-terrestriallife in environments beyond Earth, presenting them as tangible works and educational materials thatdemonstrate the stage of shift from a “Geocentric” (Earth-centered perspective) to a “Heliocentric”(perspective that could be shifted freely throughout the universe) about life.

These works are the result of collaboration between astrobiologists, authors who write based onscientific knowledge, and artists who illustrate life forms. They depict scenarios where extra-terrestriallife encounters probes sent by Earth life, viewed from the perspective of those extra-terrestrial life.

In this research presentation, we hope to not only expand on our previous studies regarding the potentialfor Microgravity environments to enhance creativity in artistic activities but also to present our newseries of works depicting possible extra-terrestrial life forms, providing an opportunity for closeencounters with participants at this symposium.

AMS965 **Design, construction, and on-orbit measurement of the power distributionunit for space utilization system of China space station**

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In view of the design characteristics of China space station, such as large number of payloads, highpower distribution voltage, diverse power supply and distribution requirements, dispersed layout,complex control, high stability and safety and reliability requirements, the power supply design proposesa space application system power distribution unit: comprehensive consideration of equipment designfactors such as layout and voltage conversion are briefly introduced, the general design scheme of thepower distribution unit is briefly introduced, and the on-orbit operating status is analyzed. The designedpower distribution unit realizes the efficient, reliable design and safe on-orbit operation of China spacestation, and can provide a reference for the design of power supply and distribution systems for worldsubsequent manned spacecraft.

AMS496 **Towards sustainable extra-terrestrial construction materials using biopolymers**

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The construction of extraterrestrial habitats presents a formidable challenge, particularly in reducingdependence on Earth-based resources. This study addresses this issue by exploring the development ofstraightforward, rapid, and environmentally sustainable manufacturing protocols to produceconstruction materials with mechanical properties comparable to those found on Earth. We focus on theutilization of biopolymers—specifically guar gum, xanthan gum, and acacia gum—in conjunction withvarious extraterrestrial regolith simulants, including LHS-1, MGS-1, LMS-1, and MGS-1S, to fabricatebricks suitable for use in space environments.

The mechanical properties of these biopolymer-regolith composites (BRC) were rigorously evaluated,revealing compressive strengths reaching up to 15 MPa and tensile strengths up to 2 MPa. These findingsare critical for standardizing the manufacturing protocol, ensuring that the produced constructionmaterials meet the necessary structural requirements for extraterrestrial applications. Furthermore, weemployed the Brazilian disc test and digital image correlation (DIC) analysis to investigate the failuremechanisms of the bricks under tensile stress, providing insights into their performance and durability.

To assess the robustness of these biopolymer-regolith consolidates, we subjected them to a range ofenvironmental conditions that mimic those encountered on the Moon and Mars. These conditionsincluded thermal exposure up to 120°C, cryogenic temperatures down to -80°C, and low-pressureenvironments ranging from 5 to 10 mbar. Additionally, we examined the impact of water saturation andsubsequent drying on the mechanical properties of the bricks, as these factors are crucial for theirperformance in extraterrestrial settings.

Our results demonstrate that the bricks retain their structural integrity and mechanical properties evenafter exposure to these extreme environmental conditions, highlighting their potential for use inextraterrestrial habitats. The combination of biopolymers and regolith simulants not only offers a viablesolution for constructing durable materials in space but also emphasizes the importance of developingeco-friendly manufacturing processes that can be easily automated and implemented in off-Earthenvironments.

Keywords: Space Habitats; Space bricks; Biopolymers; Extra-terrestrial regolith

AMS501 Heat Pump for Space Station Active Thermal Control: Merits and Challenges

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Space stations are designed to support human life in space for years. The space stations use activethermal control system (ATCS) to reject the internal heat generated due to avionics and crew metabolismand maintain the temperature of habitable volume air within a narrow range. The ATCS employmechanically pumped fluid loop(MPFL) system which collects the internal heat via air ventilationsystem and reject through radiators to deep space. Because of the intermediate resistances from sourceto sink, the radiator temperature will be much lesser than the cabin air temperature.

The radiators area available will be limited considering the size of the space station, and a furtherincrease in radiator size to increase the heat rejection capacity (HRC) may not be practical. This limitsthe total power handling of the space station. A heat pump can be used to raise the radiator temperatureabove the internal ambient temperature, which results in a higher HRC without increasing the size ofthe radiators. Preliminary analysis showed that for every 5 °C increase in radiator temperature, therewill be an increase in HRC of about 20 W/m^{2}in a typical low earth orbit environment. The trend towardsincreasing power due to more powerful devices, greater power density, and longer-term missions willnecessitate the use of heat pumps to reject heat from future space-based systems. These heat pumps mustbe able to operate in both microgravity (10-6g) and lunar (g/6) environments.

Heat pumps require much higher power to operate the compressor compared to power requirement ofconventional single phase MPFL pump. Typically, compressor requires about 50% of power that ofinternal heat load whereas MPFL pump requires only 2 to 3 % of power. Hence the use of heat pumpdemands additional rise of solar panel size (i.e. mass). Terrestrial heat pump compressors rely on gravityfor proper oil circulation in bearings, seals, and other contact surfaces, as well as proper refrigerant/oilmanagement in two-phase heat exchangers. For microgravity operation, body-force independent heatpump is of primary systems requirement. The design of compressor lubrication system, bearings,auxiliary cooling of compressor are the major challenges. Also, terrestrial compressors will have a highmass (typically 40 kg for 10 kW cooling capacity), cause excessive vibrations, may result in additionalnoise during on-orbit phase and are intended for much lower temperatures (maximum 65°C) than whatis required for the space heat pump application (~100°C). Only a

handful of vapor-compression systemsare currently flying or have flown in microgravity space environments with almost negligible on-orbitperformance reports in open literature.
In this study, thermodynamic feasibility of compression-based heat pumps and their primary sizing arepresented. Instead of ammonia-based energy systems, usability of other working fluids is studied fromthermal, safety & space-environment (e.g. radiation hardness) point of view. Based on parameters suchas, coefficient of performance, temperature lift, change of total mass of the system (radiator, compressor,solar panel) and net rise of power consumption; effectiveness of heat pump-based systems for spacestation cooling application is presented. Further, the merits and challenges in realisation and the effortsput by the other space agencies to develop heat pumps and space qualified compressors in particular arediscussed in this-study.

Keywords: Space station; Heat pump; Active thermal control system; Heat rejection capacity;

AMS819 **Production of SiC from Lunar regolith simulant**

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Mankind's quest to explore the moon is rapidly gaining momentum in recent years, with the aim of establishing a habitable extra-terrestrial base on moon. To ensure sustainability during exploration missions, it is imperative to utilize the resources available on the lunar surface such as the regolith, to build structures and components on moon. The fabrication of components on the surface of moon requires raw materials like metals, metal alloys and ceramics that must be extracted from the regolith. Since silicon is the widely abundant element next to oxygen, the extraction of silicon and its compounds seems pragmatic. Therefore, the objective of this study is to extract silicon carbide (SiC) from lunar regolith which has a wide range of applications in producing abrasives, electronics and ceramic components. The methodology involves heating the regolith to high temperatures so that volatile species such as Na, K, Fe, SiO are liberated and subsequently, the evolved SiO gases are reduced to SiC by using methane. The reaction products formed in the crucible are examined using scanning electron microscopy. It was observed that both whiskers and nanowires are formed in certain regions of the reaction crucible. The whiskers formed have a diameter of around 400 nm, with spheres of SiO2 present on its surface. The nanowires are intertwined in the form of fibres and is of diameter 100 nm approximately. The resulting whiskers and nanowires are examined using Raman spectroscopic studies and is found to be β-SiC. The SiC nanowires produced from lunar regolith can be used in fabricating semiconductor components such as LEDs and field emission devices.

Keywords: In-situ resource utilization; Lunar regolith; Carbothermal reduction; Silicon carbide

Keywords: In-situ resource utilization; Lunar regolith; Carbothermal reduction; Silicon carbide

AMS508 **Test of AC feedback controller for Tianqin mission using a torsion pendulum**

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The gravitational wave is one of the important inferences of Einstein's general theory of relativity. Now, gravitational wave detection has opened a new window for cosmic observation. Tianqin is a Chinese space gravitational waves detection mission, in which, the high-precision inertial sensor (IS) is one of the key technologies. The IS system should have a an extremely low noise resolution level and needs to be fully verified in ground experiments. This poster presents the progress of the IS developed at Huazhong University of Science and Technology (HUST) for the Tianqin mission, mainly focusing on designing and testing the control parameters for the AC feedback controller and the driving circuits of the IS system. Using a torsion pendulum facility, the test mass (TM) is controlled by the AC driving circuits and the embedded software. Closed-loop control parameters verification and related mechanical parameters calibration are also tested.

Keywords: gravitational wave, Tianqin mission, inertial sensor, AC controller, torsion pendulum.

Venue: Hall-03

Session 3B: Material Sciences

Dec-03

AMS380 **Effect of Oxygen on Surface Tension of Liquid Metals and Alloys**

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Oxygen interacts with liquid metals, decreasing surface tension by adsorption. Only a few ppm ofoxygen can reduce the surface tension significantly, and reserve its temperature coefficient. However,due to lack of techniques to directly monitor and observe oxygen at the surface of liquid metal, theunderstanding of oxygen adsorption is not so high. During the “contactless” thermophysical propertymeasurements on ISS, the liquid metal is still in contact with its surrounding atmosphere. Overcome thisissue, ESA’s Materials Science Laboratory Electromagnetic Levitation (MSL-EML) facility is equippedwith the Oxygen Sensing and Control device (OSC). Thanks to OSC, new measurements with knownoxygen potential becomes possible. Before carrying out ISS experiments, several ground basedexperiments were carried out in the frame of THERMOPHYSICAL PROPERTIES OF LIQUIDALLOYS UNDER OXYGEN INFLUENCE (OXYTHERM) Project. In this presentation, severalground-based experimental works validating the influence of oxygen on the surface tension of metalsand alloys are introduced. In addition, the advanced oxygen adsorption models (“non-ideal adsorptionmodel”, “two-step adsorption model”, and “surface modification model”)are introduced.

Keywords: adsorption; MSL-EML; OSC; surface tension;

AMS873 **Measurement Of Metal Foam Expansion in a Drop Tower**

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Microgravity significantly impacts the characteristics of metal foams by altering gravity-drivendrainage, which helps achieve a more homogeneous foam structure—a highly desirable outcome.Most microgravity studies on metal foams use parabolic flights and sounding rockets; however, thesemethods are costly and often inaccessible, limiting research in this area. A more affordable alternative is to use a drop tower. The main challenge of using a drop tower for metal foaming experiments is thelimited duration of microgravity, which restricts the observation time for the phenomena of interest.This study aims to conduct metal foaming in a drop tower and obtain conclusive insight into metalfoam expansion under the influence of microgravity.

A novel module was developed to conduct metal foaming within the drop tower to achieve this. Metalfoam expansion can be easily observed with a DSLR camera. This setup can foam multiple metalfoam samples at a single time. In this setup, foaming is only allowed in the vertical direction (alongthe -g axis) and is constricted along the horizontal direction; therefore, foam expansion is synonymouswith an increase in foam height in the context of this experiment. A cartridge heater is used with athermocouple to monitor the heating rate. All these components are secured firmly on the deck of theinner capsule with the necessary protection to avoid damage caused by the high g force during the landing of the drop capsule on the airbag. Using relays, the heater, camera, and thermocouple will beactivated in a sequence before the drop. Preliminary ground tests (under 1 g) were conducted byperforming 25 trials to observe the expansion of metal foam in 2.5 seconds. During those 2.5 seconds,the expansion of metal foams was determined. The same experiment was conducted in the drop tower.

Expansion observed during the ground test was compared with the expansion in the drop tower toquantify the effects of microgravity on the growth rate of foam expansion. This study aims toshowcase that even complex experiments, such as the measurement of metal foaming expansion, canbe performed in a drop tower. This will help to accelerate the advancement of research in the field ofmetal foams.

Keywords: Metal Foam; Microgravity; Gravity-driven drainage; Drop tower; Metal foam expansion

AMS067 Containerless Processing of High Temperature Materials on the China Space Station

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The Containerless Material Rack (CMR) on the China Space Station (CSS) was launched with theTianhe core module in April 2021. Over the past three years, it has successfully debugged and validatedkey functions of the facility, including sample release, electrostatic sample control, high-temperaturelaser heating, and the measurement of high-temperature thermal properties in microgravity conditions.The facility can melt samples with melting points near 3000K and cool them at various degrees ofundercooling to obtain different metastable phases. It employs semiconductor and oxide lasers formelting both high-temperature metal and inorganic non-metallic materials, with the semiconductorlaser's maximum output power reaching 300W. Containerless experiments can be conducted in a vacuum of 10-3 Pa and at conditions of 3 atm under argon gas. After astronauts install the sample boxinto the facility, all experimental operations are remotely controlled from the ground. A single samplebox can contain 29 samples, each approximately 3 mm in diameter.

More than ten scientific teams have completed their orbital experiments with the CMR, and the returnedsample boxes have been analyzed on Earth. The research encompasses metal materials such as metallicglass and superalloys for hyperspace applications, focusing on microgravity's effects on their structure.

Additionally, non-metal materials including high-functional glass, biomaterials, and planetary oxidematerials were studied to examine microgravity's impact on the formation of metastable phases. Theconference will present some intriguing results obtained from these studies.

Keywords: China Space Station; Containerless Processing; High Temperature Materials; Solidification

AMS311 Chemical enrichment of asteroids - Low velocity impacts in microgravity using PRL's short range drop facility

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Solar system objects experience hypervelocity (> 3 km s^{-1}) impacts from bolides that originate fromdifferent regions of the outer solar system. Especially the asteroid belt experiences a large number ofimpacts even to-date. However, the velocities that are experienced during an impact event within theasteroid belt may be even low velocity impacts (1 – 100 m s^{-1}) due to the relative velocities betweenthe smaller bodies.

Such low velocity impacts happening in the asteroid belt may require more attention as they do nothave sufficient energy to cause physico-chemical changes on the target that are usually caused byhypervelocity impactors. Given the variety of asteroids (different densities and chemical compositions)that are known to-date, the target texture could be regolith, rocky surface or a mix of regolith androcks. Such differences in the surface texture plays a role in determining the outcome of the lowvelocity impact. In addition, there are asteroids that are known to be rubble pile, whose surfaceresponse to an incoming low velocity bolide would be different.Recently, the sample return mission OSIRIS-REx, collected samples from the surface of asteroidBennu using Touch-And-Go (TAG) sample collection set to an approach velocity of 12 cm s^{-1}. Duringsample collection, the sample collection arm penetrated into Bennu's surface. The penetration to theasteroid surface was unexpected in the sample collection process.

In PRL using the short range microgravity drop facility, we recreated the asteroid surface thatexperiences microgravity conditions while a low velocity (up to 10 ms^{-1}) bolide impact on the target.

The results showed penetration of the bolides on the regolith targets while the rebound of the bolideimpacting on to the rock targets (Fig 1). The experiments carried out helped us in understanding thechemical enrichment on the asteroid bodies. Our experiments provide an explanation for the presenceof bright objects on carbonaceous asteroids which are thought to be of exogenous origin.

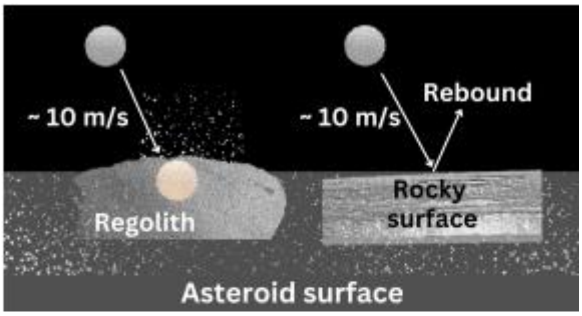

Figure 1 - Schematic of a low velocity impact on the asteroid surface containing regolith androcks.

Keywords: Asteroid; Low velocity impacts; Surface process; Chemical enrichment.

AMS348 **Multiple crystallization pathways of extremely supersaturated aqueous solution droplets on Electrostatic Levitator**

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In present study, we report the measurement of the solution structures of KH_2PO_4 (KDP) and $NH_4H_2PO_4$(ADP) in extremely high supersaturation by using the-state-of-the-art, a combination of electrostaticlevitation (ESL) and synchrotron X-ray scattering. The structural evolution of both aqueous solutionscould be successfully obtained as a function of supersaturation using in-situ synchrotron x-ray scattering.
Interestingly, we find that the solute structure abruptly changes at high supersaturation in KDP solution,which is accompanied by the molecular symmetry breaking in H2PO_4-ions from C_{2v} to C_1 assupersaturation increases. Moreover, the structural evolution of the solutes in KDP solution showsdifferent H_2PO_{4-} liking process from that in ADP solution, although they have the same crystal structureat room temperature. This manifests the existence of two different solute structures, depending on thedegree of supersaturation in the KDP solution. We also find that molecular symmetry and its structuralevolution of the solute can affect the pathways of the early-stage nucleation, which explains the differentpathways of KDP crystal formation. The present work paves a new way of studying the solute structureand its evolution in highly supersaturated solutions. This work will impact a wide range of research areafrom biology to the material science in the microgravity environment.

Keywords: Electrostatic levitation; solution structure; x-ray scattering; crystallization

Venue :Auditorium

Session 4A: Ground-based Microgravity

Dec-04

AMS617 **HFE-7100 spray cooling under microgravity: the liquid film dynamics and heat transfer**

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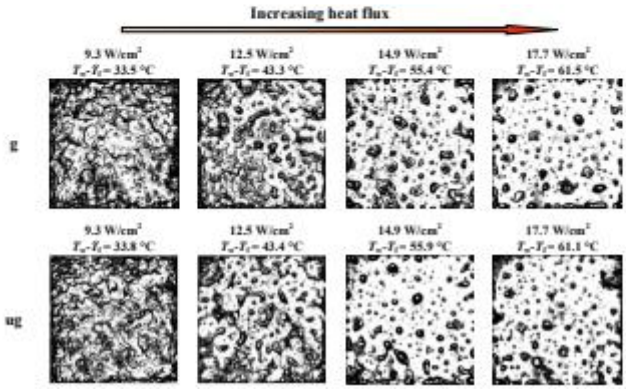
Spray cooling under microgravity is not only oriented by application in space, but also the essentialpursuit of the exploration spirit facing the unknown. This study was the first series of scientificexperiments of China New Microgravity Experiment Facility with Electromagnetic Launch. In thisstudy, the liquid film dynamics and heat transfer characteristics of HFE-7100 spray on a smooth andrough silicon surface under microgravity were quantitatively captured, including the film morphology,wetted area, equivalent diameter and the velocity under different inlet pressures and heat fluxes. Severalclassic scenarios, including the spreading liquid film, bifurcate liquid film, the liquid film bridge, thetadpole-shaped liquid film, the fusiform liquid film and the isolated liquid film, were recognized for thefirst time. The morphologies of the liquid films and the heat transfer performance under smooth andrough surfaces showed insignificant difference between the normal- and micro-gravity. In addition, thedimensionless groups (We and Re) were updated: approximately 92.4% of the total We samples andapproximately 96.4% of the total Re samples ranged from 0.01–1, and 10–300, respectively, regardlessof the different coolants (HFE-7100 and HFE-7000), pressures, nozzle-to-surface heights, heat fluxes,surface orientations and conditions,and gravities (1g and μg).



Classic behaviours of liquid films on smooth surface for P = 0.14 MPa under normal (g) and microgravity (μg)

Keywords: Spray cooling; Microgravity; Liquid film scenarios; Liquid film velocity.

AMS280 **Experimental study of flame spread behaviour over planar polymer-metal-polymer composite material in normal gravity and micro-gravity environments**

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Over the past few decades, numerous experiments have investigated the flame dynamics over a varietyof materials in microgravity environment under different oxygen concentrations and configurations.This research is crucial to study and develop fire safety protocols in spacecrafts as many processesinvolved in fire are influenced by gravity. However, there are many types of materials that remainedunexplored, despite their extensive applications in space. The present work is an experimental study toexamine the opposed flow downward flame spread phenomena over planar composite materialscommonly used in spacecrafts for food packaging, in circuit boards etc and compare the results betweennormal and microgravity environments at varied oxygen levels. The composite material studied hereconsists of three polymer layers and a metal layer sandwiched between them: PolyethyleneTerephthalate (PET) layer with a thickness of 12 μm, Aluminium foil (Al) layer of 9 μmthickness,Nylon layer of 15 μm thickness and Retort Cast Polypropylene (RCPP) layer with a thickness of 70 μm.The outer layers comprising of PET and RCPP are exposed to the environment. The 2.5 secondsmicrogravity drop tower established at the National Centre for Combustion Research and Development(NCCRD), IIT Madras is used to simulate the microgravity environment. The flame spread behavior over both sides (PET and RCPP) of the material is captured by G-rated high-speed cameras and imageprocessing is used to find the flame spread rates. The experiments are conducted at a forced air flowvelocity of 15 cm/s, speed typically encountered in spacecrafts, and at various oxygen concentrations(25% - 40%). The flame spread rates over both the sides increase monotonically with the oxygenconcentration in both normal and microgravity conditions. However, the flame spread rates over bothsides of the material is lower in microgravity than in normal gravity. In addition to this, it is observedthat flame spread rate over the PET side is higher than the RCPP side in microgravity, while the oppositetrend is observed in the normal gravity environment. Interestingly, at 40% oxygen concentration, thetrend is reversed, and the flame spread rate is higher over RCPP side in microgravity while PET sideexperienced higher spread rate in normal gravity. These findings provide valuable insights into materialbehaviour in space. The results and the scientific explanations of the flame behaviour in microgravityfrom these unique experiments will be discussed.

Keywords: Planar Composite Material; Opposed flow downward Flame spread; Drop Tower;Microgravity flame spread; Normal gravity flame spread.

AMS987 **HUST Drop Tower and Its Performance Test**

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Ground-based microgravity facilities are to study the space-related or fundamental sciences withsimulated space microgravity environment on earth. With the support of the National Precise GravityMeasurement Facility (PGMF), a vacuum drop tower was designed and constructed at HuazhongUniversity of Science and Technology. The drop tower, named HUST Drop Tower, now is open as amicrogravity experiment platform for related science experiments. This paper presents the design detailsand performance test of this drop tower. The drop tower iscomposed of a vacuum drop tube, dropcapsules, a release unit, a deceleration unit, a monitoring and control unit. It is capable of establishing avacuum environment under 10 Pa, the freefall height is more than 20 m, and the freefall time is morethan 2.0 s. A quartz-flexureaccelerometer and an electrostatic accelerometer are adopted to measure theactual microgravity level, and the experiment data was collected and analyzed.

Keywords: Drop tower; Microgravity; Accelerometer.

AMS310 Converting the Gifford Shaft in KGF into a Microgravity Drop Tube

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Experiments carried out under microgravity conditions using ground based facilities are imperative forlong term exploration of space. In fact, such facilities to simulate microgravity conditions are ofimportance in many areas that are closely related to space missions. Although there exists amicrogravity platform, PSLV Orbital Experiment Platform (POEM), in the Low Earth Orbit (LEO)using the spent stage of the PSLV launch vehicle, there is still a need for a ground based microgravitytest facility before flying experiments in LEO. Such a facility can be instrumental in validating designsand experiments to be integrated into the POEM platform and aid in development and modificationsof experiments which will be part of POEM platform.Here we propose a drop tube with one of the best drop times in the world with a drop tube height of atleast 500 m using the already existing Gifford shaft of Kolar gold mine, India. This facility cantranslate to a microgravity of ~ 10 seconds while achieving residual gravity level < 10-5. In addition, adrop mass of one tonne would make this a unique facility in the world. A ground-based microgravityfacility with such a combination of long drop time, good residual gravity and heavy drop weight willcertainly be cost effective while enabling a variety of new experiments from material science to spacebiology. The proposed facility will primarily bank on the existing Gifford shaft which provides access to avertical column that can readily house many of the components necessary for realizing the drop tubefacility. Use of the existing infrastructure will also save time while establishing a new facility.The design and development plans for all three major components namely drop tube, drop capsule anddeceleration/arrester unit will be presented in this symposium.

Keywords: Microgravity; Drop Tube; Gifford Shaft; Kolar Gold Field

AMS986

Investigation of flame behaviour on thin cellulosic fuels across different geometrical configurations and environments

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This experimental investigation focuses on the behavior of flames on thin cellulosic fuels in three geometrical configurations: planar single, planar parallel, and circular duct. Experiments are conducted in normal and microgravity environments, maintaining ambient oxygen conditions at atmospheric pressure. The planar fuels are 40 mm wide. The interspacing between parallel fuels is set at 10 mm, 14.5 mm, and 21 mm. Duct diameters are 19 mm and 38 mm. An opposed flow speed of 10 cm/s is consistently maintained during all experiments. The parallel fuel and duct configurations resulted in interacting flames which at certain separation distances showed an increased spread rate compared to the single sheet. For parallel fuels, iso-intensity contours are used to analyze the flame morphology and variations in intensity for varied separation distances.

At a short separation distance of 10 mm, flames merge quickly, but heat loss through conduction limits spread and affects oxidizer transport, preventing quenching within the short test duration. In contrast, an intermediate separation distance facilitates flame merging, enhancing the flame front size while simultaneously reducing burning intensity and temperature due to altered gas flow patterns. At a larger separation distance of 21 mm, initial intensity reduction is observed; however, as the test progresses, confinement enhances heat transfer and oxidizer availability, leading to brighter regions indicative of improved combustion efficiency. The flame spread rates exhibited non-monotonic behavior in normal and microgravity conditions influenced by separation distance and duct diameter. Interestingly, in microgravity conditions, circular ducts exhibited the lowest flame spread rates at low opposed flow speeds. This contrasts with normal gravity conditions where duct configurations showed the highest spread rates.
This is due to the improved oxygen transport to inner core region and increased heat transfer from the flame.

Keywords: Microgravity, Thin fuel, Parallel, Circular duct, Flame interaction, Iso-intensity contours Separation distance

AMS546 Microgravity-induced alterations in emulsion characteristics: An investigation into its appearance, morphology, and stability

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Emulsion is a biphasic liquid colloidal system, which under the influence of specific transformingsubstances, known as surfactants (i.e., anionic and non-ionic), adopts a macroscopic homogeneous statewhile remaining heterogeneous at a microscopic level. Based on the dispersed phase and the dispersionmedium, emulsions can be classified into oil-in-water (O/W) and water-in-oil (W/O) systems. As far asthe applicability of these biphasic systems is concerned, these systems represent one of the most widelyused formulations in the pharmaceutical industry as they not only allow the encapsulation of an activepharmaceutical ingredient (API) in the dispersed phase (and protect it from degradation), but also makethem a sustained- (SR) or controlled-release (CR) preparations, which decrease the side-effects of drugand increase patient compliance. In the context of astronauts, one of the most common drugs used bythem is Modafinil which is used to treat fatigue caused by circadian dyssynchrony (a condition thatdisrupts your body's natural sleep-wake cycle) in orbit. In such a scenario, given the long duration forwhich an astronaut has to remain in orbit, an SR or CR based, emulsion formulation of Modafinil wouldbe of great benefit, both from a logistical viewpoint and side-effect profile (such as Stevens-JohnsonSyndrome, Toxic pidermal Necrolysis, and Drug Rash with Eosinophilia and Systemic Symptoms, asreported in post-marketing surveillance studies). However, for the addition of such a newpharmaceutical formulation to the list of essential medications for space travel, it is imperative toinvestigate the probable changes in the characteristics of the emulsion(s) after being exposed toconditions of microgravity. This is so because such an analysis would help us understand whether theemulsion has undergone stability changes, such as phase separation or phase inversion, both of whichwould affect the product’s shelf life (and quality) and pattern of drug release, respectively. Therefore,the present study would aim to investigate the effect of microgravity, on emulsion characteristics. Toachieve our aim, we propose an experimental design that would make use of two sets of samples:

• GROUND CONTROL: To include simple (S) emulsions (i.e., S-O/W, S-W/O), and theirrespective marketed (M) pharmaceutical formulation (i.e., M-O/W, M-W/O).

• TEST: Similar set of samples (i.e., S-O/W, S-W/O, M-O/W, M-W/O) under parabolicflight-induced microgravity conditions.

In terms of assessing study parameters, we would be analyzing the samples for their appearance,morphology (through colorimetric values, optical microscopy, etc.), stability characteristics (throughparticle size analysis, charge analysis, rheology, etc.), and probable shifts or loss in drug content orrelease characteristics of API from marketed pharmaceutical emulsions. Therefore, our study is expectedto demonstrate whether or not microgravity conditions influence the stability and characteristicproperties of emulsions. Furthermore, we believe, that such findings, would significantly affect the drugdevelopment process of essential space travel medications, besides having implications on spacepharmacovigilance, thus offering better pharmacological treatments for astronauts.

Keywords: Microgravity, Emulsion, Pharmaceuticals, Stability.

AMS671 **Normal gravity to microgravity transition of flame spreading over thin cylindrical fuels in a drop test**

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In a typical microgravity drop test of flame spread over thin cylindrical fuels, a steadily spreading flamein normal gravity is exposed a step change in gravity, from normal gravity to a microgravity environmentfor a short duration. After a brief unsteady transition, the flame spreads steadily in microgravity up tothe end of the drop test. In this work this transition of flame spread from normal gravity to microgravityis examined experimentally and numerically. The experiments are conducted in a 2.5s microgravity droptower at NCCRD, IIT Madras. In the experiments, a steadily burning cylinders of PMMA (diameters: 0.5 mm, 1 mm, 1.5 mm, and 2 mm) and of cellulose (diameters: 0.4 mm, 0.6 mm, 0.8 mm, and 1 mm)in normal gravity conditions are subjected to sudden (step) change in gravity down to microgravity.The dynamic behaviour of flame shape (height, width), intensity, and flame spread rates during this stepchange of gravity level is captured using a digital camera. The spread of leading edge of the flame,change in geometry of flame and intensities are characterised by processing the images obtained.Selected identical experiments are also conducted in 4.7s microgravity drop tower at ZARM, Universityof Bremen and the results are compared with the results obtained in 2.5s drop tower experiments. Anin-house unsteady, CFD code developed for predicting flame spread over thermally thick cylindricalfuels is used to simulate the transition of a normal gravity flame to a microgravity flame. The dynamicbehaviours in gas phase and solid phase are studied by numerical simulations in comparison withexperimental results. The study shows that, once the gravity is removed the flame leading edge jumpsforward in upstream direction in a milliseconds. The flame stands at new position for a short time, heatsup solid fuel ahead to spread steadily. The effect of fuel diameter of the cylindrical fuels is alsodiscussed.
Keywords: Normal gravity to microgravity transition; microgravity drop test; steady and unsteadyflame spread, opposed flame spread; cylindrical fuels.

Venue :Auditorium

Session 5A: Life Science and Biotechnology-3

Dec-04

AMS436 **Seed-to-seed growth of rice on the Chinese Space Station**

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The long-term cultivation of higher plants in space plays a substantial role in investigating the effects of microgravity on plant growth and development, acquiring valuable insights for developing a self sustaining biological life supporting system(BLSS). In our pervious studies, we have finished the experiments of Arabidopsis thaliana from seed-to-seed on board the Chinese space lab TG-2. The completion of the Chinese Space Station (CSS) provides us with a new permanent space experimental platform for long-term plant research in space. Biological Culture Module (GBCM), which was installed in the Wentian experimental Module of the CSS, was constructed with the objective of growing Arabidopsis thaliana and rice (Oryza sativa) plants a full life cycle in space. Dry seeds of Arabidopsis and rice were set in root module of four culture chambers (CCs) and launched with Wentian module on July 24, 2022. These seeds were watered and germinated from July 28 and grew new seeds until November 26 within a duration of 120 days. To this end, both Arabidopsis and rice plants completed a full life cycle in microgravity on the CSS. As we know, this is the first space experiment achieving rice complete life cycle from seed-to-seed in space. Some of these seeds have been used to a subsequent experiment to susscessfully produce a second generation after returning to Earth. Germination rates for space-produced seeds were about 90%, indicating that mature seeds developed in microgravity were healthy and viable. However, problems for rice plants grown in space were also observed, such as produced fewer flowers, altered morphological structures, and smaller seeds with changed storage reserves in comparison with their controls on ground. This result demonstrates the possibility to cultivate the important food crop rice throughout its entire life cycle under the spaceflight environment. However, we are now going beyond plant survival in space, but to develop higher resource-use efficiency biological life support system, which need higher yield plants. Thus, we conclude by suggesting that a systematic analysis of molecular networks of genetic stability for adaptation of rice to long-term spaceflight and find key genes with significant application value to develop molecular level transformation of rice to cultivate new germplasm resources with high yield for establishing reliable and efficient BLSS.

Keywords: Chinese Space Station; Oryza sativa ; from seed-to-seed; Storage reverves.

AMS975

Immuno protective Role of the MAPK/PMK-1 Pathway in C. elegans in Response to Spaceflight

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Space microgravity is known to have detrimental effects on the human body, especially in physiologyand immunity, which are comparable with the aging phenotype on Earth. However, the geneticmechanisms behind these physiologic changes are not well understood. Understanding these pathwaysis important to help us develop preventive and therapeutic strategies, not just for astronauts in space butalso for the elderly and immunocompromised people on the ground. The nematode C. elegans is ananimal model for genetic studies and spaceflight experiments. In this study, we have sent C. elegansinto space aboard the International Space Station (ISS), fed with Enterobacter commensal bacteriatagged with tdTomato fluorescence. This bacterium is capable of colonizing worms with weak immunity(Berg et al., 2019), which will be a biomarker for immune decline in microgravity. Our results showedthat C. elegans has less resistance to Enterobacter colonization, which represents immune dysfunctionin space. We have also observed the same colonization pattern in simulated microgravity using a 3Dclinostat on the ground. To determine the mechanism behind this, we have used C. elegans mutants forconserved immune pathways that are known to be altered in microgravity, such as the TGFβ ligand dbl-1 and the p38 MAPK ortholog pmk-1 strains (Harada et al., 2016; Li et al., 2018). Our simulationexperiments revealed that the TGFβ/DBL-1 mutants are susceptible to Enterobacter irrespective ofgravity conditions, while the MAPK/PMK-1 mutants showed resistance to Earth gravity control butexhibited an intense susceptibility to Enterobacter in microgravity. These results were confirmed inMAPK/PMK-1 mutants that were sent into space. MAPK/PMK-1-dependent immune effector genesimportant for immunoprotection in

microgravity were also identified via RNA sequence analysis andRNA interference screening. In summary, we have discovered the immunoprotective role of theMAPK/PMK-1 pathway and identified its downstream genes in C. elegans in response to microgravity.

Keywords: C. elegans; Clinostat; Immunity; Spaceflight.

AMS992 **Can Lunar Soil Nurture Plant Growth?**

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Lunar exploration has captivated significant attention in recent times through programs such as Artemis.To establish long-term sustenance on the moon, astronauts will have to grow their food on-site. In thepresent study, we investigated whether ISRO's lunar soil simulant (LSS); LSS-ISAC-1 can nurture cropplants. We assessed the germination and seedling growth response of four important crops—wheat,tomato, groundnut, and cotton to LSS. Our findings revealed that plants significantly struggled with lowgermination, stunted seedling growth, and increased oxidative stress. This baneful phenotypic and biochemical issues stemmed from LSS’s acidic pH, low Electric Conductivity (EC), and severe nutrientdeficiency. To mitigate these problems and alleviate inherent toxicity, we enriched LSS with varyingamount of CP – 3.125%, 6.25%, 12.5%, 25%, 50%, and 100%. The results showed that LSSsupplemented with 6.25% CP in wheat and tomato; 3.125% CP in groundnut, and 25% CP in cotton significantly improved phenotypic and biochemical traits in seedlings. As anticipated, all four cropsthrive well on earth soil (ES) and CP per se, outperforming the LSS. This study underscores cocopeat'spotential as a promising additive to support crop growth in lunar soil, advancing the in-situ resourceutilization (ISRU) strategy for lunar agriculture.

Keywords: Lunar Soil Simulant; Plant growth; Cocopeat; Keyword

AMS541

An investigation into the function of AtLAZY1 in modulating the interplay between gravitropic and phototropic signaling pathways in Arabidopsis

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The environmental parameters of light and gravity exert a significant influence on plantgrowth and development. In order to optimize the availability of light, plants orient their stems in amanner that is parallel to the light source and perpendicular to the gravitational vector. A potentialcompetition exists between the effects of gravity (gravitropism) and light (phototropism) within plant organs. Furthermore, the tropisticsignalling elicited by these stimuli may interact with oneanother. The limited knowledge of the interaction of these tropistic stimuli is a consequence of theubiquitous nature of gravity on Earth, which presents a challenge in studying the effect of light inisolation from the influence of gravity. In recent decades, research into the LAZY gene family has made a significant contribution to our understanding of plant gravitropism. Here, the Col-0Arabidopsis and atlazy1 mutant were transported to the Chinese space station aboard the SZ-14spacecraft. It was observed that the microgravity environment in space was effective in restoringthe prostrate growth phenotype of the atlazy1 mutant. In addition, micro-expression of the AtLAZY1 protein in barley endosperm revealed that the nuclear-localized AtLAZY1 protein canbind to its own promoter DNA, thereby exerting a transcriptional regulatory function. DAP-seqsequencing, in conjunction with in vitro EMSA, revealed that the AtLAZY1 protein not only directlybinds to the auxin polar transport PIN protein but also negatively regulates the expression of NPH4,a core phototropism signaling protein. Promoter-deletion assays, in conjunction with screening of ayeast one-hybrid library of Arabidopsis transcription factors, demonstrated that the core protein PIFs,which are downstream of the light signal, are capable of binding. It can be concluded that theAtLAZY1 protein plays a pivotal role in the signal transduction mechanisms underlyinggravitropism and the regulation of phototropism in plants. In conditions of normal gravitationalforce (1 g), the influence of gravity on plant architecture and branching angles is more pronouncedthan that of phototropism. However, in the context of spatial microgravity, the absence of gravitational forces enhances the role of AtLAZY1 in the negative regulation of phototropism,thereby compensating for the atlazy1 mutant phenotype, which is characterized by large branchingangles, by augmenting phototropic responses. This study is of great significance to ourunderstanding of the antagonistic role of AtLAZY1 in the

signals of gravity and light, and to the regulation of plant architecture.

Key words: Gravitropism,Phototropism,LAZYprotein,Microgravity,Plant architecture.

AMS879

Microbial Regolith Experiment: Passive Recoverable Payload for Microbial Experiments for Space based Applications

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Effect on microbial growth due to microgravity conditions is gaining interest in space research for a long time. Microbes, specifically those that induce a process called calcite precipitation, have been rarely studied for its effect on microbial growth upon exposure to hypergravity or microgravity conditions for a certain time period in space. One such microbe to be studied in this work is an Anaerobic Bacterium which exhibits bio-cementation process. The *MICP (Microbially Induced Calcite Precipitation*) process has been successfully demonstrated in developing consolidated structures using multiple grades of lunar and martian soil simulants under terrestrial conditions. Termed 'Space Bricks', these consolidates can demonstrate significant compressive strength, like that of ice under sub-freezing conditions.

The proposed experiment exposes a bacterial spore and regolith mixture to hyper-gravity, and, after retrieval, culture cells in growth media to measure the mRNA and protein expression kinetics of Urease production. It will also assay levels of ammonia and biocarbonate in the media, measure the ability of cells to import urea by extraction of cells, measuring urease enzyme kinetics and intracellular concentration of urea and use XRD to measure the crystal size of CaCl2 on spores that have been exposed to hyper-gravity as compared to those that have not.

Our payload, *MRX - an acronym for Microbial Regolith EXperiment* is a general purpose self-contained platform for performing experiments with micro-organisms in space/microgravity conditions and it doesn't require any electronic power equipment to operate it during spaceflight. It is designed to incubate bacteria in milli-fluidic containers called 'cassettes'. The platform is designed to be modular and stackable with each cassette housing 7 experimental wells.

Upon Recovery from space, a transfer mechanism is also developed so as to transfer the mixture from the cassette and then provide each experimental well with nutrient media, which triggers the growth of the bacteria, thereby inducing calcite precipitation, subsequently producing the consolidate structures dubbed 'Space Bricks'.

The Payload will have 3 stages, with each stage housing an experimental cassette, enclosed inside a larger casing. The 1st cassette will incubate the bacterial spores, stored in a growth-prohibiting sucrose medium in 6 wells. The 2nd and 3rd cassette delves into the study of Lunar Mare Simulant (LMS) regolith-spore mixture and Mars Global Simulant (MGS) regolith – spore mixture respectively. The cassettes are seated in cylindrical housing and are completely sealed from the environment.

We have also subjected the payload design to various structural and thermal Finite Element Analysis(FEA), like Modal, Random Vibration, Sine Vibration, Re-entry Shock Spectrum and Splashdown Impact, so as to check whether the design is able to meet the qualification criteria set for Recoverable Payloads.

Keywords: Microgravity; Hypergravity; Bacteria; MICP; Regolith; Simulant; Space Bricks; Payload; Millifluidic; Cassette; Transfer Mechanism; FEA;

AMS993

Mathematical Modelling of Bone Disuse under Space Microgravity

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The microgravity environment of space flight enforces sudden unloading of load-carrying bones (e.g., lower limbs, neck) coupled with fluid shift towards the upper extremities of the body, leading to depletion of body fluids and nutrients for bone remodeling. Moreover, the alterations in the digestive and cardiovascular systems change the availability of healthy nutrients for bone growth. The effect of mechanical loading alterations can deteriorate the mechanical properties and deplete the cellular-level nutrients, known as bone disuse (degradation). We have recently developed a 3-dimensional theory of morpho-elastic growth combining nutrient distribution. The same can be extended to study the disuse of bone in space microgravity. This paper develops a 2-dimensional bone disuse model from the 3-dimensional theory. Moreover, volumetric and interfacial constitutive laws coupling biomechanics and biochemistry are introduced. This proposed morpho-elastic model of bone disuse includes complete mechanical-driven growth and nutrient chemistry in microgravity. The proposed model considers the effect of body metabolic rate and fluid shift through biochemistry. Since bone growth is strain-driven and influenced by the state of residual stress, the same is also included in the model as biomechanical stimuli. Numerical simulation results are reported showing the state of residual stress, growth strains, and nutrient chemistry just before reaching the orbit and after a long stay in the orbit.

Keywords: microgravity; bone disuse; biological growth and remodeling; residual stresses; strain driven growth; biomechanics and biochemistry coupled constitutive laws

Venue: Hall-03

Session 4B: Material Sciences

Dec-04

AMS989 **In-Situ Observations of Crystal Growth from Solutions by High-Resolution Optical Interferometry**

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In order to understand the difference of crystal growth mechanism from solutions, various in-situmethods have been developed and employed for space experiments using ISS, sounding rockets,aircrafts, drop shafts with the reference of ground based experiments. When the supersaturate of thesolution is not extremely high, namely, not in the regime of volume diffusion controlled, the growthrates of crystals under microgravity were equal or larger than the rates in normal gravity, if we measuredthe growth rate with the resolution of 0.001nm/s. Surface morphologies of these crystals were alsoobserved in-situ at various growth conditons. These results have been interpreted based of the couplingeffects of diffusion rates of solute and impurity molecules.These works have been conducted with thehelp of many colleagues, students, agencies and companies.

Keywords: Crystal Growth; In-Situ Observation; Growth Mechanism; Protein Crystal

AMS073 **Surface Oscillation of Molten Oxide Droplet by Electrostatic Levitation Furnace (ELF) installed in ISS**

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On the ground-based electrostatic levitation method, a strong electric field of about 10 kV allows acharged sample to be levitated in free space by Coulomb forces in the opposite direction to gravity. Theformation of an electric field by high voltage requires levitation in a high vacuum of about 10-4 Pa. In amicrogravity environment, the Coulomb force due to the strong electric field against gravity is no longernecessary, so electrostatic levitation is possible in a gas atmosphere without needing a high vacuum.

The electrostatic levitation furnace (ELF) has been installed in the Japanese Experiment Module Kiboon the International Space Station (ISS) to measure the thermophysical properties of molten oxides [1].

Thermophysical properties of a welding flux model material consisting of SiO2-CaO-Mn3O4-TiO2 weremeasured using the ELF. Under the 2.0x105 Pa of Ar or dried-air conditions, a sample was kept at itsposition at the center of the electrode in the ELF, and a sample was heated up and melted bysemiconducting lasers with 980 nm wavelength. The pyrometer measured the sample temperature witha 1.45-1.8 μm wavelength and an emissivity of 1.0. The apparent temperature by the emissivity of 1.0was corrected using our measured emissivity values of molten oxides [2]. The surface oscillations wereexcited by 1kV AC electric fields with several frequencies.The oscillating drop method was applied to obtain their surface tension and viscosity, and thedifferences in basicity were discussed. To obtain surface tension and viscosity, an oscillating electricfield must be applied to forcibly excite the surface oscillation and measure the free oscillation frequencyand decay time after the oscillating electric field is stopped. When the frequency of the applied ACelectric field resonates with the natural frequency of the surface oscillation of the droplet, largeamplitude oscillation can be obtained, and the damping of the surface oscillation is easily measured. Onthe other hand, if the applied frequency deviates from the resonance condition, the amplitude becomessmall, and it is necessary to investigate the relationship between the deviation of the frequency of theapplied AC electric field from the resonance condition and the damping of the surface oscillation. In thecase of highly viscous droplets, the surface oscillations decay quickly, and a sufficient number ofoscillations cannot be obtained. In this study, the damping time and frequency of surface oscillation ofmulti-component molten oxide measured using ELF were analyzed non-dimensionally, and the accuracyof the surface tension and viscosity values were investigated.

Reference

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of Molten Oxide Using an Electromagnetically Levitated Complex Droplet of Molten Oxide and Liquid
Fe, High Temp. High Press., 52 (2023) 249.

Keywords: Electrostatic Levitation; Surface Oscillation; Molten Oxide

AMS864 **Microgravity crystal growth experiments on board the International Space Station and Recoverable Satellite**

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InGaSb ternary alloys are technologically important because of their tuneable lattice constant(6.096 ~ 6.479 Å) and wavelength (1.7 ~ 6.8 μm), between their binary constituents InSb and GaSb, inthe infrared (IR) region. However, the growth of high-quality InGaSb is affected by segregation becauseof the large difference between liquidus and solidus temperatures of In-Ga-Sb solid solution. Tounderstand the dissolution kinetics and growth properties of multi-component alloys with varyingsegregation coefficients, microgravity experiments were performed on board the International SpaceStation (ISS) and Chinese recoverable satellite (CRS; SJ-10 space program). InxGa1-xSb crystals withlower (x = 0.04) and higher (x = 0.11) segregation coefficients were grown by a vertical gradient freezingmethod using a GaSb(seed)/InSb/GaSb(feed) sandwich system on board the ISS and CRS, respectivelyand the results were compared with ground experiments. The ISS experiments revealed that convection under normal gravity enhanced seed dissolutionwhereas the dominant diffusion under microgravity enhanced the dissolution of feed crystal. Thedissolution of GaSb feed occurred to a greater extent along the (1 1 1)B plane than along the (1 1 1)Aand (1 1 0) planes. The dissolution kinetics were anisotropic and its geometry was independent oforientations. The growth rate was observed to be higher along (1 1 1)B than along (1 1 1)A and (1 1 0),and the growth rate of the (1 1 0) lied in-between the (1 1 1)B and (1 1 1)A experiments. The shapes of initial and final growth interfaces, the dissolution tendency of the seed and feedcrystals, and growth kinetics of this CRS experiment were similar to the long duration microgravityexperiments performed at the ISS. This provides an evidence for the repeatability and reproducibility ofthe microgravity experimental results.

The experimental results revealed that convection under normal gravity is helpful to achieve asteady state in melt composition. However, the non-steady state of equilibrium in the melt compositionunder microgravity could be helpful for better dissolution and crystallization kinetics that resulted inhigher growth rate. These longer duration microgravity experiments demonstrate the possible utilizationof space environment for manufacturing complex materials with enhanced quality.

Keywords: InGaSb; Crystal Growth; Microgravity experiment; Growth kinetics

AMS231 The effect of magnetic field on solidification process of metal under microgravity condition

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In the traditional metal preparation process, metal materials are always accompanied by defects such as uneven grains and segregation. The use of magnetic field to control the metal solidification process can significantly improve the performance of metal materials, but the solidification process will inevitably be affected by gravity on ground, thus covering up the effect of magnetic field on metal. With the development of space science and technology and the establishment of the Chinese Space Station, the high temperature material science experiment rack (referred to as the high temperature rack) deployed in the Mengtian space module can be used to carry out space material science solidification experiments, which can provide a high temperature experiment environment up to 1200℃, and can provide experimental conditions such as isothermal, gradient temperature field mode and rotating magnetic field. The magnetic field can be used to actively control the melt flow during the preparation of space materials, and the mechanism of magnetic field on metal solidification can be revealed more clearly under microgravity conditions.

In order to provide references for space microgravity experiments and explore the influence of magnetic field on metal materials, a multi-mode magnetic field device was used on the ground to apply magnetic field during the solidification process of binary tin-lead alloy, and metal solidification experiments were carried out under different experimental conditions by adjusting the magnetic field intensity, magnetic field mode, magnetic field direction and other parameters. The grain morphology and segregation of the experimental samples were analysed, and the differences and composition distribution of the grains under different magnetic fields were observed. The finite element analysis software was used to adjust the relevant parameters to simulate the metal solidification process, which provided a reference for the subsequent space microgravity experiments of multi-component alloys.

Keywords: Microgravity; Rotating magnetic field; High temperature cabinet; Metal solidification.

AMS542 **Effect of Magnetic Field on the Glass Forming Ability of ZBLAN glass**

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ZBLAN glass is from the family of Heavy Metal Fluoride (HMF) glass family: its most stable glass composition is ZrF_4 (53%)-BaF_2 (20%)-LaF_3 (4%)-AlF_3 (3%)- NaF (20%). It has very wire range of applications in mid IR, and telecommunication. But because of devitrification, still best possible glass is far from its theoretical best. Some work has been tried in reduced gravity and also has positive impact on the crystallization mechanism. But the magnetic Field (MF) also expected to have the positive influence on the reduction in the crystallization. Glass Forming Ability (GFA) of ZBLAN glass will be calculated with varying MF and without MF. Three ways are used to find the glass forming ability namely kinetic GFA, structural GFA, and thermodynamic GFA. Differential Scanning Calorimetry (DSC) will be done for the glass to find the various GFA parameters. In the low magnetic fields kinetic GFA is improving and structural GFA is getting reduced. While the thermodynamic GFA along with other two GFA again be calculated at higher fields also. Then the glass forming ability in MF and terrestrial condition will be compared. Experiments are being going on for remaining higher fields.

Keywords: Differential Scanning Calorimetry (DSC); ZBLAN; Magnetic field; Glass Forming Ability (GFA).

AMS991 **Impact of microgravity on droplet transfer in the GMAW-Based DED-Arc process under low welding currents**

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Metal additive manufacturing is essential for long-duration space missions, providing the capability for in-situ fabrication of tools and replacement components. Gas Metal Arc Welding (GMAW)-based Directed Energy Deposition (DED)-Arc is a highly effective method for additive manufacturing, particularly in intravehicular settings where standard atmospheric pressure facilitates arc welding. Its high deposition rate makes it a preferred method over other available DED-Arc processes. In intravehicular conditions with limited power availability, using low current welding is a feasible solution. At lower current levels, metal transfer generally occurs in globular mode, where the droplets are larger than the electrode diameter. In a typical flat welding position, with non-short circuit transfer, the gravitational force, Lorentz force, and plasma drag generally assist in droplet detachment, while surface tension and vapor pressure typically act to resist it. Although all these forces influence droplet behaviour, the gravitational force is the primary factor controlling droplet transfer in globular mode, highlighting the significance of this investigation.

This study uses a 2.5-second freefall drop tower setup featuring a capsule-in-capsule system to simulate reduced gravity conditions. The welding setup comprises a GMAW power source, 2.8 kVA Uninterruptible Power Supply (UPS), a welding chamber with a traverse system, argon canister, and a high-speed camera, all securely mounted inside the inner capsule to endure the high g-forces experienced during rapid deceleration. A bead-on-plate deposition is carried out using a 1.2 mm diameter ER4043 filler wire and an Al6063 baseplate, with 99.999% pure Argon employed as the shielding gas. The capsule is held at the release point until the welding process stabilizes, after which the drop is initiated. Welding then continues under reduced gravity condition until the capsule lands on the airbag after 2.5 seconds. In addition to the high-speed images, welding current, voltage and acceleration values are recorded. The images are synced with this data for indicating the onset of microgravity. The high-speed camera setup is calibrated with a checkerboard pattern, and the captured images are analysed to determine the droplet transfer frequency and droplet diameter. One lower welding current value (120 A) is employed to examine the impact of current on droplet transfer in a reduced gravity environment. The results from the drop tests are compared with the ground trial values for the droplet transfer parameters. Regardless of the gravity conditions, reducing the current results in a lower droplet transfer frequency and a larger droplet diameter. Under the same welding parameters, droplets generally grows larger and the frequency of droplet transfer decreases in reduced gravity compared to a 1 g environment. This phenomenon becomes more pronounced as the current is decreased from 140 A to 120 A. This is due to the fact that as the current decreases, the Lorentz force weakens, making the gravitational force increasingly important for droplet detachment. This study provides a comprehensive overview of the impact of microgravity on droplet transfer in low current metal deposition scenarios, especially for additive manufacturing in intravehicular environments.

Keywords: Low current welding, GMAW-based DED-Arc process, microgravity, droptower, droplet transfer

Venue: Hall-03

Session 5B: Combustion-2

Dec-04

AMS138 **Effects of low pressure and oxygen on low stretch diffusion flame extinction of a cellulosic material**

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Since inevitable use of multiple materials in spacecraft, fire safety in microgravity environments is very important. In particular, the environmental pressure and oxygen conditions of the next generation of spacecraft will change, which will further complicate the problem. In the absence of buoyancy effect in microgravity conditions, a fire is usually initiated at low stretch rates due to a low forced flow velocity via the spacecraft ventilation system or crew movement. However, in a terrestrial environment, the buoyancy force usually precludes the low stretch flame to be established. Based on previous theoretical researches, the extinction limit with fuel/oxidizer mole fraction versus stretch rate typically shows a C shape curve, exhibiting a turning point. Different mechanisms contribute to high and low stretch flame extinctions. There are many studies on high stretch flame extinction, however, few studies on low stretch flames due to the difficult in obtaining low stretch flames under normal gravity. Considering the high cost and limited availability of microgravity experiments, it is desirable to develop a ground-based method to simulate microgravity conditions. Foutch and T'ien proposed a buoyancy-induced stretch rate concept (ab∝(g/R)-1/2, where g is the gravitational acceleration and R is the sample radius), which can simulate microgravity low stretch flames by establishing flames in the stagnation-point region of a large curved fuel sample.

Based on the buoyancy-induced stretch rate theory, this work used a cylindrical filter paper sample as the fuel with larger radius of curvature, low stretch flames (ab: 12-26 s-1) were established in the stagnation-point region. Ambient pressure and oxygen concentration were adjusted in a sub-atmospheric pressure test chamber (55-101 kPa, 11.5-15.5% O2 in volume). The present study addressed the effects of thermal and chemical kinetics on the near-extinction-limit burning characteristics and extinction mechanisms of the low stretch flames under the combined effects of pressure (P) and oxygen. The critical flame standoff distance was proved to be inversely proportional to the square root of partial oxygen pressure (ppO2) times stretch rate. As the stretch rate and pressure increased, the critical flame temperature increased and the critical oxygen concentration (XO2crit) decreased, due to decreased gas phase radiative loss and increased reactant leakage, respectively. Two non-dimensional parameters: critical Damköhler number (Dacrit) and heat loss ratio (Floss), were examined to characterize flame extinction. Dacrit remained constant at varied stretch rates, but decreased with reduced pressure. Quenching occurred at lower pressures and stretch rates with Floss > 50%, dominated by heat loss. On the contrary, flame blowoff was controlled by chemical reaction when Floss < 50%. At the extinction limit, ppO2/P represented the diffusion-controlled reaction rate, which was higher at lower stretch rates. Flames could survive above these reaction rate limits but extinguish below them. This fundamental study could improve the understanding of cellulosic materials extinction limits under conjugate effects of various external environmental variables. In particular, the results for these relatively low stretch flames may be used in future spacecraft materials screening tests.

Keywords: Microgravity fire safety; Extinction limit; Pressure and oxygen; Low stretch rate.

AMS346

SMOKE CHARACTERIZATION FROM DIFFERENT SPACECRAFT MATERIALS IN NORMAL GRAVITY AND MICROGRAVITY ENVIRONMENT

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Space exploration involving humans brings in the necessity for better understanding of spacecraft health and fire safety concerns in microgravity environment. In the present study, experiments are conducted to investigate characteristics of soot particles from different spacecraft materials under flaming and smoldering conditions in the normal gravity and microgravity environment. The microgravity experiments are conducted using 2.5 s drop tower facility, available at the National Center for Combustion Research and Development, IIT Madras, India. The generated soot particles from different polymers are sampled in normal gravity and microgravity environments, and analysed using Scanning Electron Microscope (SEM). To estimate the quantitative data of soot volume fraction, laser extinction method is adopted. As the detection of soot is found to depend on the convective air flow, there is small convective flow of air at 15 cm/s is provided during the sampling. This also ensures that the soot that is being sampled/observed, is only the soot produced in microgravity and not the soot that is produced before the drop. Preliminary results from the experiments show that, soot particles formed in microgravity environments are larger in size compared to that in normal gravity.

Keywords: Soot particles, Microgravity, Fire safety, Spacecraft materials.

AMS294 **Study on flame blowout and turbulent transition characteristics of non-non-premixed jet flames**

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The study of turbulent transition and flame structure of non-premixed jet flames under microgravityconditions is one of the scientific experimental projects of the combustion chamber inspaceapplication systems. This paper conducts research on the space experimental conditions designfortheproject. Firstly, a theoretical analysis of the flame blowout of jet flames was conducted, exploringtheflame blowout velocities of different fuels such as methane, ethylene, and propane at various tubediameters, and experimental verification was performed. The results indicate that the flame blowout velocity increases with the increase in tube diameter. Furthermore, the study reveals that the blowout characteristics of flames are related to fuel viscosity and calorific value; under the same tube diameter, methane is the most easily extinguished, followed by propane, with ethylene having the highest blowout velocity. Secondly, an experimental study was conducted on the transition characteristics offlames from laminar to turbulent flow for different fuels at different tube diameters. The flame height variation with jet Reynolds number was obtained for methane, ethylene, and propane at various tubediameters (with jet orifice diameter ranging from 0.4mm to 1mm). From these patterns, the transitioncharacteristics from laminar to turbulent flow for different fuels at different tube diameters wereidentified. The experimental results show that methane requires the largest tube diameter for transition, with minimal flame lift-off. Ethylene can achieve turbulent transition at a 0.4mmtube diameter, withno flame lift-off during a single ignition, where the Reynolds number for turbulent transition is 1638, and the average turbulent flame height is 158.9mm. However, during independent ignition at flownodes, flame lift-off occurs, reducing the Reynolds number required for turbulent transition, andthepost-transitional flame height decreases, with the Reynolds number for turbulent transition being1942, and the average turbulent flame height being 116.5mm. It was also found that the ignitionheight exhibits a linear negative correlation with the Reynolds number required for turbulent transition. Propane can undergo turbulent transition and flame lift-off at 0.4mm, with single and multipleignitions having minimal impact on turbulent transition and flame lift-off, maintaining a consistent average turbulent flame height. Finally, the influence of diluent addition on the transitioncharacteristics of jet flames from laminar to turbulent flow was studied. The incorporation of diluent gas can reduce flame height but leads to an increase in the tube diameter required for turbulent transition. The mixture of 80% propane and 20% nitrogen increases the required tube diameter forturbulent transition to 0.6mm.

Keywords: Non-Premixed Flames; Jet Flames; Flame blowout; Turbulent Transition; Jet ReynoldsNumber

AMS839 **Study on flame spread near flame-spread limit considering cool flame in microgravity**

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Elucidation of the spray combustion mechanism will contribute to higher combustion efficiency and accurate simulations. In order to elucidate it, the flame-spread experiments over randomly distributed droplets were conducted in the Japanese Experimental Module "Kibo" aboard the International Space Station and the group-combustion excitation was investigated. Around the group-combustion-excitation limit, Mikami et al. (2021) reported that there appear two types of anomalous behavior: large-scale ignition and re-burning by a slow flame propagation in a burned area and both phenomena include the possibility of a cool-flame appearance. Cool flame is a low temperature oxidation reaction around 700 K for hydrocarbon fuels. Mikami et al. (2006) experimentally researched that Mode3 flame spread appears in such limit of flame spreading. In this mode, the next droplet is ignited by heat from the diffusion flame whose leading edge does not reach the flammable-mixture layer around the next droplet. Mikami et al. (2023) investigated the appearance of the cool flame in droplet-cloud elements. This study used a mid-wave infrared camera to observe the cool flame.

Based on these results, this research focused on the cool flame appearance in Mode3 flame spread and investigated the effect of inter-droplet distance and temperature distribution to understand the mechanism of flame spreading near the flame spread limit. When the cool flame appears, very weak luminescence with visible to near ultraviolet wavelength range is emitted. Therefore, we have to use an intensified camera to amplify the signal. However, this method cannot avoid risks of image sensor damage by the hot-flame appearance. The problem can be solved by using a mid-wave infrared camera as it can capture the infrared light emission from the combustion products, CO2 and H2O, which have peak wavelength in mid-infrared region. By comparing the mid-wave infrared image and high-speed camera image with a back-illumination, we can distinguish the hot flame and the cool flame.

In this research, we use liner droplet arrays consisting of three droplets (one droplet for ignition and two droplets for flame spread observation) and n-decane as a fuel in room temperature and atmospheric pressure. Comparing the high-speed camera images and the infrared images, the area of infrared luminescence is much larger than that of the diffusion flame. Some of the results, we observed weak infrared luminescence around the unburned droplet. By analysing the infrared luminance value around the unburned droplet, it has smaller peak than that around the ignited droplet and surrounded the unburned droplet so we judged it is from the cool flame. Moreover, we conducted other experiments in different droplet distances and droplet diameters and then compared the luminescence with different conditions to clarify the mechanism of cool flame appearance and flame spreading.

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Keywords: Flame spread; Cool flame; Infrared radiation; Droplet combustion

AMS826

Numerical study on combustion characteristics of Methyl Methacrylate(MMA) Pool Flames in Microgravity Environment

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A study on combustion of flammable materials used in space, that may burn in microgravity environment is indispensable to understand flame characteristics/fire risk, and to design devicesto avoid fire and explosion inside the spacecrafts. One such widely used spacecraft material is Poly Methyl Methacrylate (PMMA). It undergoes thermal degradation when its temperature reaches around 250^oC to 400^oC and forms condensed monomer (MMA) as a dispersed layer over its surface. Therefore, studying the combustion behaviour of liquid MMA pool would be helpful to understand PMMA combustion. This study enables understanding of flame characteristics, heat transfer mechanism and soot production in MMA pools burning in microgravity (zero gravity) environment. Experimental measurements of parameters such as mass loss rate is extremely challenging in microgravity environment. Thus in this study, numerical simulations are employed for analysing the burning and soot formation of MMA pool flames. For this, a comprehensive numerical model built on Ansys FLUENT, which has been well validated for predicting the burning of MMA pool flames in normal gravity, as reported by this group in literature, has been considered. This model incorporates heterogeneous interface boundary conditions for predicting the steady burning rate of a liquid fuel (using a user defined function), a detailed MMA kinetic mechanism having 49 species that predicts all the required features of gas-phase reactions, simple soot and radiation sub-models, multi-component diffusion, and variable thermo-physical properties.

First, numerical simulations of burning MMA pools in zero gravity and standard air (21% oxygen by volume) environment has been carried out. Combustion in normal and zero gravity conditions is compared using mass loss rate and soot production. Reasons for the trends have been explained using temperature and species fields. Reduction in burning rate and increase in soot formation in zero gravity air environment are clearly shown. Further, the effects of ullage, which is the distance between pool surface to the container surface, have also been studied. Furthermore, variation in oxygen level has been considered to study its influence in burning of MMA pool in zero gravity.

Keywords: microgravity; MMA; liquid pool; soot formation; ullages.

AMS857 **Experimental Study on Small-Scale Low-Intensity Turbulent Combustion under Normal Gravity**

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The study of small-scale weak turbulence under microgravity is one of the scientific experimental projects in the combustion chamber of space application systems. This paper conducts ground experimental research targeting the design of space experimental conditions for this project. Firstly, the possibility of turbulence generation by grids is investigated, and the turbulence intensity at different installation positions of grids with varying mesh sizes in the combustor is studied. The PIV flow field measurement technique based on a continuous laser and a high speed camera is used to obtain the characteristics of the cold flow field, and the turbulence intensity is obtained through data analysis. The results show that at the same installation position, the grid can generate turbulence, and the turbulence intensity first increases and then decreases as the mesh size increases.

An excessive number of grids homogenizes the jet flow. Secondly, the diffusion flame structure under varying nozzle outlet velocities, ambient oxygen concentrations (21%, 25%, and 30%, respectively), and a fixed mesh size of 50 meshes is studied. In the experiments, the flame temperature field and soot concentration field are obtained using the flame self - luminous emission spectroscopy method. The distribution characteristics of the radicals OH and CH are obtained using an ultraviolet camera combined with 310 nm and 430 nm narrowband filters. Variations in flame color and morphology under different jet velocities and ambient oxygen concentrations are observed, and the effects of ambient oxygen concentration and jet velocity on flame height are determined. The results indicate that the flame color gradually changes from blue to bright yellow as the jet velocity increases, suggesting an increase in soot production in the flame with increasing jet velocity.

As the oxygen concentration increases, the flame color gradually changes from bright yellow to bright white. The flame height increases with increasing jet velocity and decreases with increa sing oxygen concentration. The OH concentration reflects the reaction zone of the flame, while the CH concentration reflects the degree of completeness of combustion. The experimental results show that as the mesh size increases, the trends in CH and OH concentrations align with the trend in turbulence intensity of the jet, first increasing and then decreasing. Compared to flames without grids, the CH and OH concentrations are significantly lower. As the oxygen concentration increases, the OH and CH concentrations also increase, leading to more intense combustion and higher flame temperatures.

Keywords: Microgravity; Turbulent Combustion; Grid-Generated Turbulence; Ground-Based Experiments

AMS738

Numerical simulation for flow field around a flame spreading over an electric wire placed in a ground-based centrifuge

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Fire safety is one of the most important issues in a manned space mission. The flammability of solid materials in the microgravity environment has been studied by FLARE (Flammability Limits At Reduced-g Experiment) project. In the Artemis program, on the other hand, astronauts will be sent to Moon or even Mars in the future. Therefore, the fire safety of bases in partial gravity environments, which are different from the microgravity or Earth ground environments, should be ensured. However, the flammability of solid materials in partial gravity environments has not been clarified yet. In FLARE 3 project, which is the following project of FLARE project, we are developing the space experiment apparatus for low gravity environment flammability of solid materials employing a centrifuge. It was predicted that the non-uniformity of centrifugal force and a Coriolis force in the space experiment apparatus significantly affect the flow field inside the apparatus in the development process of the apparatus. To investigate the effect of non-uniformity of centrifugal force and a Coriolis force in the centrifuge on flame spread characteristics of solid material in detail, a ground test apparatus employing centrifuge was developed and experiments of flame spread over an electric wire have been conducted [1]. The apparatus is designed to be able to apply centrifugal forces of up to 10 G at the position of the solid material sample.

In this study, the numerical simulations reproducing the flow fields inside the ground test apparatus employing centrifuge were conducted. The accuracy of the simulations was validated by comparing the flow field predicted by the simulations and the flow pattern visualized by the laser sheet and the tracer particles at the experiment. The flame tilt angles predicted by the simulations and that observed at the experiment were also compared, and it was concluded that the simulations could well reproduced the flow field inside the test apparatus. As a result of the analysis of the flow field predicted by the simulations, it was found that the flow fields inside the apparatus have complicated structures due to the Coriolis force and the radial distribution of the centrifugal force. It was also found that the large-scale rotating flow inside the chamber was formed due to the effect of the Coriolis force.

[1] Yusuke Konno, Shoryu Ishikawa, Nozomu Hashimoto, Osamu Fujita, Downward flame

spread and extinction over electric wires placed in a ground-based centrifuge, Proceedings of the Combustion Institute, Vol. 40, Paper No. 105199, 2024, DOI: https://doi.org/10.1016/j.proci.2024.105199

Keywords: Partial gravity; Fire safety; Flame spread; Centrifuge; Coriolis force

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Venue: Hall-03

Session 6B: Construction & Manufacturing in space-2

Dec-04

AMS879

Microbial Regolith Experiment: Passive Recoverable Payload for Microbial Experiments for Space based Applications

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Effect on microbial growth due to microgravity conditions is gaining interest in space research for a long time. Microbes, specifically those that induce a process called calcite precipitation, have been rarely studied for its effect on microbial growth upon exposure to hypergravity or microgravity conditions for a certain time period in space. One such microbe to be studied in this work is an Anaerobic Bacterium which exhibits bio-cementation process. The MICP (Microbially Induced Calcite Precipitation) process has been successfully demonstrated in developing consolidated structures using multiple grades of lunar and martian soil simulants under terrestrial conditions. Termed ‘Space Bricks’, these consolidates can demonstrate significant compressive strength, like that of ice under sub-freezing conditions.

The proposed experiment exposes a bacterial spore and regolith mixture to hyper-gravity, and, after retrieval, culture cells in growth media to measure the mRNA and protein expression kinetics of Urease production. It will also assay levels of ammonia and biocarbonate in the media, measure the ability of cells to import urea by extraction of cells, measuring urease enzyme kinetics and intracellular concentration of urea and use XRD to measure the crystal size of CaCl2 on spores that have been exposed to hyper-gravity as compared to those that have not. Our payload, MRX - an acronym for Microbial Regolith EXperiment is a general purpose self-contained platform for performing experiments with micro-organisms in space/microgravity conditions and it doesn’t require any electronic power equipment to operate it during spaceflight. It is designed to incubate bacteria in milli-fluidic containers called ‘cassettes’. The platform is designed to be modular and stackable with each cassette housing 7 experimental wells. Upon Recovery from space, a transfer mechanism is also developed so as to transfer the mixture from the cassette and then provide each experimental well with nutrient media, which triggers the growth of the bacteria, thereby inducing calcite precipitation, subsequently producing the consolidate structures dubbed ‘Space Bricks’.

The Payload will have 3 stages, with each stage housing an experimental cassette, enclosed inside a larger casing. The 1st cassette will incubate the bacterial spores, stored in a growth-prohibiting sucrose medium in 6 wells. The 2nd and 3rd cassette delves into the study of

Lunar Mare Simulant (LMS) regolith-spore mixture and Mars Global Simulant (MGS) regolith – spore mixture respectively. The cassettes are seated in cylindrical housing and are completely sealed from the environment.

We have also subjected the payload design to various structural and thermal Finite Element Analysis(FEA), like Modal, Random Vibration, Sine Vibration, Re-entry Shock Spectrum and Splashdown Impact, so as to check whether the design is able to meet the qualification criteria set for Recoverable Payloads.

Keywords: Microgravity; Hypergravity; Bacteria; MICP; Regolith; Simulant; Space Bricks; Payload; Millifluidic; Cassette; Transfer Mechanism; FEA

AMS852 **New Space Industries for 'Untact' Society**

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We have seen the first wave of new space industries in rocket launches and satellite services such as SpaceX, Rocket Lab and Planet Labs. Compared to traditional space missions mostly driven by government funding, new space industries with significant cost reductions arose from private funding such as venture capitals and IPOs. Nevertheless, their rapid growth has raised challenges in international regulations at many levels including space debris, planetary protection and the legal frame work for space utilization. Eventually we need to be prepared both legally and industrially for interplanetary civilization. In this regard, we are expecting the second wave of new space industries, which will enable space habitation and manufacturing for the eventual space colonization. However, we have not gained enough interests and concerns from the terrestrial industries and governments.

The concept of 'untact' society was originally proposed to promote the digital connection with increasing contactless consumer market trends. It became very popular during COVID-19 pandemic period with physical distancing enabled by digital technology such as internet, IoT and robotic automation. The need for technologies that enable remote work and telehealth had never been greater. Unmanned space missions have been the driving force for technology innovation for robotic automation and truly remote work over space. Long-term manned space missions like lunar and Martian expeditions may demand advanced medical technology more than current telemedicine. If we reflect on the success story of the first wave of new space industries, the proper alignment of advanced consumer technology developed from terrestrial industries and profitable space industry targeted for space utilization must be the focal point of due diligence. However, the hindsight of the first-wave new space industries should be implemented well before the realization of space colonization such as lunar and Martian habitats. It will be essential to prevent the potential pollution and exhaustion of international space resources as humanity expands its activities beyond Earth. Given the increasing interest in space exploration and commercial ventures, the existing international protocol such as COSPAR planetary protection and UN Outer Space Treaty may need to be amended. Moreover, the technological and political approach to benefit humanity both beyond Earth and here on Earth should be taken to address global challenges and improve the quality of life, leveraging the advancement in space exploration.

In conclusion, this talk will discuss how technologies for untact society must be aligned to

enable the second wave of new space industries. Space & microgravity industries have long been at theforefront of innovation, pushing the boundaries of what is possible in harsh and remote environments. If we admit the interconnectedness and the finite nature of our own planet, Earth itself is a spaceship or a space station. Well-aligned biotech companies with strong digital technology may provide the solutions for food and healthcare problems, enabling circular and sustainable economy
both on Earth and in space. Hence we suggest that the global challenges such as aging population and global warming be also reframed and solved in this new space industries and untact society perspective.

Keywords:untact; digital connection; physical distancing; space habitation; circular economy; Committee on Space Research (COSPAR)

AMS993 **Mathematical Modelling of Bone Disuse under Space Microgravity**

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The microgravity environment of space flight enforces sudden unloading of load-carrying bones (e.g., lower limbs, neck) coupled with fluid shift towards the upper extremities of the body, leading to depletion of body fluids and nutrients for bone remodeling. Moreover, the alterations in the digestive and cardiovascular systems change the availability of healthy nutrients for bone growth. The effect of mechanical loading alterations can deteriorate the mechanical properties and deplete the cellular-level nutrients, known as bone disuse (degradation). We have recently developed a 3-dimensional theory of morpho-elastic growth combining nutrient distribution. The same can be extended to study the disuse of bone in space microgravity. This paper develops a 2-dimensional bone disuse model from the 3-dimensional theory. Moreover, volumetric and interfacial constitutive laws coupling biomechanics and biochemistry are introduced. This proposed morpho-elastic model of bone disuse includes complete mechanical-driven growth and nutrient chemistry in microgravity. The proposed model considers the effect of body metabolic rate and fluid shift through biochemistry. Since bone growth is strain-driven and influenced by the state of residual stress, the same is also included in the model as biomechanical stimuli. Numerical simulation results are reported showing the state of residual stress, growth strains, and nutrient chemistry just before reaching the orbit and after a long stay in the orbit.

Keywords: microgravity; bone disuse; biological growth and remodeling; residual stresses; strain driven growth; biomechanics and biochemistry coupled constitutive laws

AMS508 **Test of AC feedback controller for Tianqin mission using a torsion pendulum**

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The gravitational wave is one of the important inferences of Einstein's general theory of relativity. Now, gravitational wave detection has opened a new window for cosmic observation. Tianqin is a Chinese space gravitational waves detection mission, in which, the high-precision inertial sensor (IS) is one of the key technologies. The IS system should have a an extremely low noise resolution level and needs to be fully verified in ground experiments. This poster presents the progress of the IS developed at Huazhong University of Science and Technology (HUST) for the Tianqin mission, mainly focusing on designing and testing the control parameters for the AC feedback controller and the driving circuits of the IS system. Using a torsion pendulum facility, the test mass (TM) is controlled by the AC driving circuits and the embedded software. Closed-loop control parameters verification and related mechanical parameters calibration are also tested.

Keywords: gravitational wave, Tianqin mission, inertial sensor, AC controller, torsion pendulum.

Venue: Hall-04

Poster Session -1C

Dec-03

AMS690 **Algae in Space: How Microgravity affects edible microalgae**

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Extended space missions necessitate the implementation of sustainable and operational life support systems that ensure the well-being of astronauts. The majority of Earth's ecosystems rely on photosynthetic organisms, which utilize light energy to convert carbon dioxide into organic macromolecules. The term 'microalgae' generally encompasses both cyanobacteria and microalgae. While plants are in fact essential for providing sustenance and oxygen, microalgae possess numerous advantages over plants that make them highly appealing as a potential commercial technology on Earth and for space travel. These advantages include accelerated growth rates, reduced nutritional needs, the capacity to be cultivated on waste materials, and the generation of multiple valuable by products. These organisms possess the ability to transform light and carbon dioxide into biomass, making them highly valuable for inclusion in life support systems within space habitats. The microalgae cultures are known to thrive in the CO2-rich atmosphere and high levels of radiation, utilizing it for photoautotrophic growth. Additionally, they can simultaneously produce numerous resources, including oxygen and food. Microalgae are beneficial in closed-loop life support systems as they perform photosynthesis to produce oxygen and consume carbon dioxide exhaled by astronauts, so successfully contributing to air renewal. Moreover, these microalgae have the potential to function as a sustainable food and nutrient source, generating consumable biomass that is abundant in proteins, vitamins, and crucial fatty acids.

Keeping in mind these advantages, we have proposed that three indigenous robust algal species, isolated from wastewater, marine water, and cold areas in India, will be sent to the ISS. Simultaneously, the same set of microalgae will be cultured on Earth for 9 days under the same conditions as on the ISS. On the last day of the mission, an aliquot of algae culture will be collected by centrifugation, frozen and stored at -70 °C (using facilities available on the ISS), and transported back to the ICGEB New Delhi lab. The frozen samples will then be processed to extract RNA, DNA, and proteins for omics studies. The physiochemical, morphological, and omics (transcriptomics, proteomics, and their interatomic) profiles of algal species returned from the ISS will be compared with those on

Earth. The comparative study of microalgae on the ISS vs. Earth is expected to improve algae for better survival in space and for the production of novel molecules of industrial importance. The information will further help in the selection of the most robust algae for future cultivation in space for sustainable food production. By harnessing the distinctive qualities of microalgae, space agencies, and researchers can accelerate the progress of creating self-sufficient ecosystems that are crucial for prolonged space exploration, colonization, and the eventual creation of human habitation on other celestial bodies.

Keywords: microalgae; space food; ISS; high value bio products.

AMS291 **Customised hardware for Fruit Fly Experiments onboard Gaganyaan Flights**

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The Gaganyaan mission represents a significant milestone in India's space exploration efforts with one of its goals of advancing our understanding of fundamental sciences through series of microgravity experiments. In sharp contrast to the life science experiments performed in Earth laboratories, any experiment involving a ‘live component in space’ demands custom-built hardware that caters to both the requirements of the biological specimen and trajectory-specifics of the mission. The present article details on the development of a fully autonomous hardware designed to transport fruit flies (Drosophila melanogaster) to a 400km orbit, on board the developmental flight of Gaganyaan and bring them back to Earth after the stipulated duration of the mission. An in-depth analysis of the hardware developed for this purpose, detailing its design, materials, and testing protocols are presented. The hardware in question is an intricate assembly that was designed to house over 500 fruit flies, providing an environment to ensure their survival during the entire span of the mission and maintaining experimental integrity. The system comprises several key elements: a primary cage structure, two side lids, damper units, fly vials with caps, transparent view windows, and various fasteners. Each component was meticulously crafted from bio-compatible materials to ensure that the fruit flies are not adversely affected by their environment or by potential contaminants.

Design considerations for this space biology hardware were driven by two main prerequisites: the specific needs of the biological specimens and the ability to withstand the rigors of launch and splash down loads with minimal disturbance to the experiment. The internal payload, which houses the fruit flies, presents additional challenges related to contamination control and life support within the crew module. To address these challenges, the hardware features multi-level containment systems and effective life-support mechanisms. The primary cage, constructed from Al6061 aluminum alloy followed by Class B anodization, provides a robust and stable environment for holding the vials. Inside the cage, the fruit flies along with their food are contained within twenty polystyrene vials, each sealed with cellulose-based breathable caps. The vials arrangements facilitated visual monitoring through the polycarbonate side windows. Vibration isolation, another critical aspect of the design, was ensured by appropriate placement of damping units that serve dual functions: securing the vials in place and attenuating vibrations that could otherwise compromise the experiments during launch, space travel and splash down. The cage is equipped with strategically placed holes that are covered with stainless steel mesh(<100 micron) to facilitate air transfer from the crew module and to provide two levels of containment. To ensure the efficacy and safety of the hardware, a scale-down model was designed and subjected to rigorous testing that assessed both the biocompatibility of the materials and functionality of the design under simulated space conditions. The results confirm that the hardware meets all necessary launch load requirements and functional criteria, ensuring the successful transport and study of fruit flies in space.

In conclusion, the autonomous hardware designed for the Gaganyaan mission effectively addresses the unique challenges of space biology experiments using fruit flies as the test specimen. Its robust design, combined with comprehensive testing and attention to bio-compatibility, positions it as a critical component for advancing our understanding of biological processes in fruit flies in microgravity environments.

Keywords: Spaceflight hardware; Gaganyaan; Fruit fly; Microgravity; Space biology

AMS997 **Advancement in Protein Crystallization in Drug Discovery and Development through Microgravity Research**

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Protein crystallization is crucial for structural biology, providing detailed atomic insights into biomolecular structures that drive drug discovery and design. However, on Earth, gravitational forces often influence the growth of protein crystals by introducing defects, limiting size, and reducing resolution. Microgravity environments, such as those present at the International Space Station, have been used to improve protein crystallization and counteract these challenges.

In microgravity, the absence of convection and sedimentation allows the formation of larger and more uniform crystals with fewer defects. This results in high–quality protein crystals which enable detailed structural analysis using techniques like X-ray crystallography, neutron diffraction, and cryo-electron microscopy. Such detailed structural data helps in understanding protein interaction, binding sites, and functions, which makes microgravity important for this study.

In structure-based drug design, microgravity protein crystallization plays a vital role. Space-grown crystals provide more detailed data on the drug binding site, which helps in the development of site specific target proteins, in the enhancement of drug potency and reducing side effects. It can benefit research for diseases like cancer, and neurodegenerative disorders. Microgravity advanced the research on membrane protein and large protein complexes which are difficult to crystallize on earth. Important membrane protein G- protein-coupled receptors (GPCRs) are critical drug targets, and their improved crystallization in microgravity offers new insights into their structure and function. Microgravity-grown crystals of pathogens help in the development of antiviral vaccines. Microgravity protein crystallization is transforming structural biology and drug discovery, driving innovations in drug development and improvised medicines. The microgravity environment offers a unique platform for the development of various protein therapeutics, allowing researchers to study and improve protein stability, structure, and function. While monoclonal antibodies (mAbs) are one significant area of focus, other types of protein therapeutics like enzyme therapeutics, cytokines and growth factors, hormonal therapeutics, protein vaccines, peptide therapeutics, and protein based drug delivery system.

Conducting protein crystallization experiments in microgravity environment requires specialized equipment like vapor diffusion plates, diffusion chambers, or microcapillaries to grow crystals. These experiments need precise temperature control, provided by incubators and freezers (like MELFI and SABL) to ensure optimal conditions. Samples are preloaded and sealed to prevent contamination, and the systems are often automated to minimize crew involvement. Radiation shielding protects the sensitive proteins, while careful handling during launch and return ensures the crystals aren't damaged. The equipment must be lightweight, compact, and safe to avoid any risks to the crew or the ISS environment. This presentation will include impact of microgravity on protein crystallization, application in drug discovery, case studies and positive outcome and future direction of research.

Keywords: Microgravity Crystallization; Protein Structure; Protein Therapeutics; Drug Discovery.

AMS673 **Design and Realization of Zero-g backup support fixture for Satellite Reflectors RF characterization**

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This work provides a design of Zero-g backup support fixture for a Communication spacecraftto enable zero gravity environment to it’s 03 nos of DPM (Deployment point mechanism) reflectors. Thedesign optimization arose due to load capacity limitation of the existing DUT (Device under test) and largemoment support requirement for this satellite reflectors. Structure hardware is constructed using lightweight AEP (Aluminum Extruded Profiles), extremely well surface finished milled components, standardMild steel, fasteners etc. Backup support fixture is designed individually to support both side reflectors,and designed to assure all reflectors tip deflection less than 5 mm. Before S/c mounting on DUT, asimulation mass attached to the reflector attachments tip points and self-deflection is measured using LaserTracker measurement technique. These deflections were within anticipated designed limit and correctionmade before satellite actual mounting on this MGSE. These reflectors are attached with DPM (Deploymentpoint mechanism) hinge and hold down mechanism, under stowed condition on their respective satellitedeck. The CATF (Compact Antenna Test Facility) consists of DUT (Device Under Test) positioner, Mainreflector, Sub reflector and Feed system. The satellite is mounted on DUT positioner inside chamber duringtest. The S/c reflectors are then deployed during antennae measurements in CATF. In deployed mode,reflector’s whole weight due to one ‘g’ on earth will act on hinge/ DPM while, DPM is designed for on-orbit configuration, where gravity effects are nil. The one ‘g’ effect on deployed reflectors may result inreflector sag also. The sag in 2.2 m diameter S/C reflector is estimated approx. 0.5□ from hinge. This causesa large error to measurement during testing. Therefore, reflectors must be supported for gravity by suitablegravity compensation method. This mechanical zero-g backup structure therefore, has shown remarkableusefulness in providing on-orbit simulation of zero-g for all 03 reflectors during CATF test of acommunication spacecraft.

Keywords: CATF- Compact Antenna Test Facility, DUT- Device Under test, DPM-Deployment pointmechanism

AMS016 **Influence of Simulated Microgravity on the Courtship and Negative Geotaxis Behaviour of Drosophila melanogaster**

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Drosophila melanogaster, also known as the fruit fly, is a highly sought model organism in biological study, both in Earth and space laboratories due to its genetic similarities to more complex creatures and its ability to offer insights into intricate biological processes. The study of fruit flies' behaviourunder microgravity, particularly their inherent escape response, provides vital insights into their overall physiology and immunological function. An intriguing behaviour to study is negative geotaxis, an inherent reaction in which flies automatically migrate upwards when moved below. This behaviour serves as a vital survival mechanism, enabling flies to evade predators by swiftly flying away from the ground. Under typical Earth conditions, negative geotaxis is a thoroughly known and dependable behaviour. Nevertheless, under the distinctive setting of microgravity, this conduct can be substantially modified, and these modifications can serve as an indication of underlying changes in their neurological and muscular systems. Given the strong connection between immunological responses and the normal functioning of these systems, studying alterations in negative geotaxis can offer valuable information on the potential impact of microgravity on the immune system. To investigate these aspects under simulated microgravity conditions, we employed Canton-S strain flies and conducted climbing assays. After treating flies for varying hours in simulated microgravity conditions using a random positioning machine (RPM), we observed that a smaller number of flies crossed the target line in a specific span of time as compared to the control set.

Another set of study widely used to explore the genetic basis and the role of environmental factors on flybehaviour is courtship behaviour. Since we are interested in developing Drosophila disease models, study of courtship behaviour under altered gravity conditions can provide useful clues to investigate the sexual dysfunction reported in several neurodegenerative disorders like Parkinson’s disease, Alzheimer’s and other dementias. Towards this goal, series of experiments were conducted using Canton-S strain male flies exposed to varying durations of microgravity in an RPM and following standard protocols, the results will be presented in detail. These observations have importance not just in the

field of space biology, but also in enhancing our overall comprehension of how organisms adjust to severe settings. Studying how microgravity affects the behaviour, physiology, and immunity of Drosophila can provide valuable insights to bioastronautics research towards preserving the well-being of humans during extended space missions. Additionally, these discoveries could have wider ramifications for comprehending how terrestrial life may react to alterations in gravitational pressures, offering valuable insights that could be used in other disciplines, ranging from medicine to evolutionary biology.

Keywords: Simulated microgravity; Drosophila melanogaster; Negative Geotaxis; Courtship assay; Space biology; Bioastronautics.

AMS034 **Investigating the oxidative stress response to improve phycocyanin production in Synechococcus elongatus UTEX 2973 under simulated microgravity conditions**

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Drosophila melanogaster, also known as the fruit fly, is a highly sought model organism in biological study, both in Earth and space laboratories due to its genetic similarities to more complex creatures and its ability to offer insights into intricate biological processes. The study of fruit flies' behaviourunder microgravity, particularly their inherent escape response, provides vital insights into their overall physiology and immunological function. An intriguing behaviour to study is negative geotaxis, an inherent reaction in which flies automatically migrate upwards when moved below. This behaviour serves as a vital survival mechanism, enabling flies to evade predators by swiftly flying away from the ground. Under typical Earth conditions, negative geotaxis is a thoroughly known and dependable behaviour. Nevertheless, under the distinctive setting of microgravity, this conduct can be substantially modified, and these modifications can serve as an indication of underlying changes in their neurological and muscular systems. Given the strong connection between immunological responses and the normal functioning of these systems, studying alterations in negative geotaxis can offer valuable information on the potential impact of microgravity on the immune system. To investigate these aspects under simulated microgravity conditions, we employed Canton-S strain flies and conducted climbing assays. After treating flies for varying hours in simulated microgravity conditions using a random positioning machine (RPM), we observed that a smaller number of flies crossed the target line in a specific span of time as compared to the control set.

Another set of study widely used to explore the genetic basis and the role of environmental factors on flybehaviour is courtship behaviour. Since we are interested in developing Drosophila disease models, study of courtship behaviour under altered gravity conditions can provide useful clues to investigate the sexual dysfunction reported in several neurodegenerative disorders like Parkinson’s disease, Alzheimer’s and other dementias. Towards this goal, series of experiments were conducted using Canton-S strain male flies exposed to varying durations of microgravity in an RPM and following standard protocols, the results will be presented in detail. These observations have importance not just in the field of space biology, but also in enhancing our overall comprehension of how organisms adjust to severe settings. Studying how microgravity affects the behaviour, physiology, and immunity of Drosophila can provide valuable insights to bioastronautics research towards preserving the well-being of humans during extended space missions. Additionally, these discoveries could have wider ramifications for comprehending how terrestrial life may react to alterations in gravitational pressures, offering valuable insights that could be used in other disciplines, ranging from medicine to evolutionary biology.

Keywords: Simulated microgravity; Drosophila melanogaster; Negative Geotaxis; Courtship assay; Space biology; Bioastronautics.

AMS998 **Space Pharmaceutical Development: The Emergence of a Promising Era for Pharmaceutical Industry**

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Space pharmaceutical research is important area for research as it has calibre to implement novelmethods of treatments, lifesaving interventions, rehabilitation of vulnerable populations and use of portable diagnostics. Moreover, space medicine research is useful on the Earth as well to provide newdrug delivery method, new treatment and new diagnostics.Scientists are using two main platforms for drug research; one is space stations and another is remotecontrolled satellites which are known as nano/micro satellites.Studies examine cell cultures, microalgae, fungi and plants among others that help to understand howmicrogravity affects different organisms.Throughout space missions, bone demineralization develops at a typical rate of 0.5% per month, withbones that carry weight, particularly the hip region, undergoing a greater rate of 1.7% per month. To setthis in its proper context, untreated osteoporosis in postmenopausal women may result in 1.5% reductionin bone density annually. The space microgravity atmosphere, combined with the severity of bone loss, provides a unique chance for the research and advances in osteoporosis medication discovery anddevelopment activities.Calcium may exit the bones during microgravity, raising the risk of hypercalciuria and kidney stones.Dehydration, dietary choices (especially high sodium and animal protein intake), restricted movement,elevated calcium excretion due to bone atrophy, reduced urination, genetic predisposition, loweredurinary citrate levels, and the surrounding temperature all contribute to the higher possibility of kidneystone formation in microgravity. The most common type of kidney stone development is calciumoxalate, followed by struvite and uric acid stones. The results of space-based research on kidney stone formation have emphasised the value of kidney stone prevention strategies for lowering the risk ofkidney stones on Earth.According to research, 60% of astronauts have a reduction in their near and far eyesight during and afterspace missions, with some vision problems continuing for years. Astronauts often experienceophthalmological problems such as globe flattening and optic disc swelling. These unusual conditionsare frequently known as Spaceflight-Associated Neuro-Ocular Syndrome (SANS). Surprisingly, severalSANS-like ocular defects, including as choroidal folds and optic disc edema, have been connected toearthly disorders like idiopathic intracranial hypertension. Since there is this similarity, research intoSANS could be capable to offer insights into circumstances identical to Earth, potentially leading toimproved cures and prevention measures.The risk of radiation-induced carcinogenesis has a significant likelihood of developing and is predictedto cause adverse impacts on the long-term quality of life after flying. Multiple protein crystal growthresearch carried out in microgravity to research proteins associated in cancers such as leukemia, breastcancer, skin cancers, and those caused by the KRAS gene, which accounts for 30-40% of all cancers.The accurate structural data from space-grown crystals has led to the development of possible treatmentsfor several illnesses, including muscular dystrophy, breast cancer, periodontal disease, and tuberculosis.Space-grown crystals have assisted in the identifying the structure of therapeutic targets, guiding thecreation of more effective treatments with fewer adverse effects.The microgravity environment in space provides a unique and ideal platform for bacterial research, asit replicates conditions found in the human body, such as high acidity resulting from metabolic byproducts and a low-shear stress environment. Microgravity can lead to changes in bacterial physiologyand resistance behaviour, including increased expression of virulence factors, enhanced biofilmformation, and decreased susceptibility to antibiotics. It is well reported that in microgravity conditions,secondary metabolite production has been observed to increase many folds.By considering all above factors, in AMS 2024 poster presentation I will cover different case studiesabout space pharmaceutical manufacturing.

Keywords: space environment; space pharmaceuticals manufacturing; osteoporosis; neuro-ocularsyndrome; cancer, monoclonal antibodies, antibiotics

AMS976 Characterization of Ions in Martian Soil Simulants Using an Interdigitated Capacitive Sensor

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The study of Martian soil is essential for both assessing the planet's potential to support life and gaininginsights into its geological history and current environmental conditions. Understanding the ioniccomposition of Martian soil can reveal crucial information about the presence of water, the processesthat have shaped the Martian surface, and the environmental dynamics that continue to influence ittoday. In this research, we focus on developing and characterizing an interdigitated capacitive sensordesigned specifically to analyze the ionic content of Martian soil samples. The sensor is intended todetect and quantify the concentration of ions present in soil that has been diluted with deionized (DI)water within a chemical wet bench environment.The sensor’s design is compact and efficient, making it suitable for integration into the chemical wetbench of Martian rovers, where space and power are at a premium. When Martian soil is introduced intothe wet bench and mixed with DI water, the sensor measures variations in capacitance caused by thedissolved ions.

These variations are directly related to changes in the dielectric constant of the solution,which in turn depend on the concentration and type of ions present. To ensure accurate ioncharacterization, the sensor was calibrated using a series of experiments where ions were dissolved inDI water at varying concentrations. This process simulates the conditions expected in Martian soilanalysis and helps in fine-tuning the sensor’s sensitivity to changes in dielectric properties.While the primary objective of this study is to accurately quantify ion concentrations in Martian soil,the sensor also shows potential for differentiating between various ionic species based on their uniquedielectric signatures. However, this capability is considered exploratory and secondary to the main goal.The results demonstrate that the interdigitated capacitive sensor provides a reliable and sensitive methodfor analyzing ionic content in Martian soil, offering significant potential for real-time, on-site analysisduring future Mars missions. This approach not only advances our understanding of Martian soilcomposition but also has broader implications for environmental chemistry and

space exploration.

Keywords: Martian soil composition; Ionic content analysis; Interdigitated capacitive sensor; Chemicalwet bench; Dielectric properties; Capacitance measurement; Ion concentration; Soil analysis; Marsexploration.

Venue: Hall-04

Poster Session -2C

Dec-04

AMS465 **Microgravity-Induced Alterations in H9C2 Cells: A Comprehensive Study on Cellular Responses, miRNA Expression, and Amelioration by bioactive compound of Ficus religiosa**

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In the celestial realm of space, microgravity bestows upon its subjects the extraordinary sensation of weightlessness. Within this unique environment, intricate alterations in cellular physiology unfold, casting a profound impact on the very fabric of life. This study investigates the impact of microgravity on H9C2 cells, a rat cardiomyoblast cell line, focusing on various cellular and molecular parameters. The research encompasses cell culture, cytoskeletal arrangement, reactive oxygen species (ROS) production, mitochondrial membrane potential (MMP), antioxidant capacity, and the expression of different microRNAs (miRNAs). Additionally, the potential of bioactive compound of Ficus religiosa to mitigate microgravity-induced cellular damage is explored.

In the sanctum of our experiment, cardiomyocytes of the H9C2 lineage were meticulously nurtured in the crucible of DMEM, enriched with 10% FBS and 1% penicillin-streptomycin, amidst an atmosphere infused with 5% CO2, maintaining a constant temperature of 37°C. cytoskeletal integrity was assessed through immunofluorescence staining, revealing significant alterations in actin filament organization. ROS levels were quantified using fluorescence-based assays, indicating a marked increase in oxidative stress under microgravity. MMP was evaluated using JC-1 dye, showing a decrease in mitochondrial function. Cell viability assays demonstrated reduced survival rates, correlating with increased oxidative damage. The antioxidant capacity of H9C2 cells was measured using the FRAP assay, which showed a decline under microgravity conditions. Nitric oxide production, assessed through the Griess reaction, was also found to be elevated, suggesting an inflammatory response. miRNA profiling revealed differential expression of several miRNAs, implicating their role in the cellular response to microgravity.

To counteract the adverse effects of microgravity, bioactive compound were administered to the H9C2 cells. These demonstrated significant antioxidant properties, reducing ROS levels and restoring MMP. Cell viability improved markedly, and cytoskeletal organization was partially restored. Furthermore, the expression of stress-related miRNAs was modulated, indicating a protective effect of the Ficus religiosa. In conclusion, this study provides a comprehensive analysis of the impact of microgravity on H9C2 cells, highlighting the critical role of oxidative stress, mitochondrial dysfunction, and miRNA regulation. The findings suggest that Ficus religiosa offer a promising therapeutic approach to mitigate microgravity-induced cellular damage. This research contributes to our understanding of cellular adaptation to microgravity and underscores the potential of natural compounds in space medicine.

Keywords: Fluorescence microscopy; ROS; MMP; quercetin.

AMS542 **Effect of Magnetic Field on the Glass Forming Ability of ZBLAN glass**

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ZBLAN glass is from the family of Heavy Metal Fluoride (HMF) glass family: its most stable glass composition is ZrF_4 (53%)-BaF_2 (20%)-LaF_3 (4%)-AlF_3 (3%)- NaF (20%). It has very wire range of applications in mid IR, and telecommunication. But because of devitrification, still best possible glass is far from its theoretical best. Some work has been tried in reduced gravity and also has positive impact on the crystallization mechanism. But the magnetic Field (MF) also expected to have the positive influence on the reduction in the crystallization. Glass Forming Ability (GFA) of ZBLAN glass will be calculated with varying MF and without MF. Three ways are used to find the glass forming ability namely kinetic GFA, structural GFA, and thermodynamic GFA. Differential Scanning Calorimetry (DSC) will be done for the glass to find the various GFA parameters. In the low magnetic fields kinetic GFA is improving and structural GFA is getting reduced. While the thermodynamic GFA along with other two GFA again be calculated at higher fields also. Then the glass forming ability in MF and terrestrial condition will be compared. Experiments are being going on for remaining higher fields.

Keywords: Differential Scanning Calorimetry (DSC); ZBLAN; Magnetic field; Glass Forming Ability (GFA).

AMS819 **Production of SiC from Lunar regolith simulant**

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Mankind's quest to explore the moon is rapidly gaining momentum in recent years, with the aim of establishing a habitable extra-terrestrial base on moon. To ensure sustainability during exploration missions, it is imperative to utilize the resources available on the lunar surface such as the regolith, to build structures and components on moon. The fabrication of components on the surface of moon requires raw materials like metals, metal alloys and ceramics that must be extracted from the regolith.

Since silicon is the widely abundant element next to oxygen, the extraction of silicon and its compounds seems pragmatic. Therefore, the objective of this study is to extract silicon carbide (SiC) from lunar regolith which has a wide range of applications in producing abrasives, electronics and ceramic components. The methodology involves heating the regolith to high temperatures so that volatile species such as Na, K, Fe, SiO are liberated and subsequently, the evolved SiO gases are reduced to SiC by using methane. This resulted in the formation of β-SiC- whiskers which are verified by XRD and Raman analysis. The morphology and characteristics of the β-SiCwhiskers are investigated by SEM, EDS, TEM and SAED techniques. SEM images reveal that the SiC whiskers are formed by both VLS and VS mechanisms with diameters ranging from 0.5 microns to 4 microns. The SiC whiskers produced from lunar regolith can be used as raw material to fabricate ceramic components and composite structures on the surface of moon.

Keywords: In-situ resource utilization; Lunar regolith; Carbothermal reduction; Silicon carbide

AMS996 SPACE MEDICINES: ARE THEY EFFECTIVE DURING HUMAN SPACE MISSIONS?

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Space medicine is a crucial field that focuses on the health and well-being of astronauts during space missions. Today, various missions, that is mars mission, study of exoplanets, and the development of space tourism are taking the future lead. Space remains one of the last frontiers for human exploration.

Crewmembers on spaceflight missions use medications to prevent or treat medical problems associated with space environment and to treat complaints like space motion sickness, sinus congestion, constipation, headache, back pain, cardiac abnormalities, upper respiratory tract infection, musculoskeletal trauma, corneal irritation, insomnia, allergies, etc. It is probable that the effects of medications administered to crewmembers during spaceflight are distinct from those observed on Earth. Right now, The International Space Station (ISS) is a large, habitable spacecraft that orbits Earth and serves as a research laboratory, observatory, and living space for astronauts. The ISS medicine formulary is specifically designed list of medications that are available for use on the International Space Station (ISS). This formulary is carefully curated to include a wide range of medicines that astronauts might need to treat various medical conditions during their time in space. This formulary consists of 111 total medications divided into 5 different medical kits. Each medical kit is colour coded. The medication list includes the convenience medication pack having 23 medications, the emergency medical treatment pack having 4 medications, the oral medication pack having 36 medications, the topical & injectable medication pack having 37 medications and the vascular contingency medication pack having 11 medications. The effects of pharmaceuticals on physiology are influenced by the spaceflight environment. The extent of the physiological systems that are affected by spaceflight and the degree of change that experienced suggest that it is probable to see changes in pharmaceutical action. The likelihood of encountering issues increases when exploration missions lengthen. The second issue is that medications must have their integrity maintained in order to guarantee that each dose has an appropriate quantity of active compounds and that the amount of drugs that degrade into toxic compounds is kept to a minimum. Medicines in space are subject to various environmental factors like radiation, humidity, oxygen, temperature can facilitate physical and chemical degradation of drugs and can significantly impact their stability,potency, and overall effectiveness. Drug degradation is a major cause of concern to hold long term space missions. Key factors contributing to drug stability issues in space and the implications for space missions are cosmic radiation, microgravity, temperature variations, humidity and vacuum conditions, drug excipient interactions etc. On the ISS, regular resupply missions can be helpful to replace medications, but for long-duration missions, it is not feasible, making drug stability a perilous issue.Therefore, in this poster we will discuss about different factors responsible for altered effect of medicines during space travel. We will also discuss about countermeasures through innovative formulations strategies, packaging system and continuous drug monitoring strategies, which can ensure that astronauts have access to safe and effective medications throughout their missions in space. Continuous advancements in space medicine are crucial for supporting long-duration missions and future deep space exploration with better medical support to astronauts.

Key Words: ISS medicine Formulary, altered effect, stability, microgravity, Drug Degradation, space radiation

AMS185 **Mechano-transduction and gene expression in microgravity: an integrated MechSigFlow pipeline for bio-fluid dynamics and T-cell signaling**

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Space exploration has long intrigued humanity, and recent technological advancements have drastically reduced launch costs, fueling a significant increase in space research and human spaceflight endeavors. Despite these advancements, the unique environment of space introduces several risks due to the effects of reduced gravity on astronauts and leads to various physiological changes, including bone demineralization, musculoskeletal atrophy, space anemia, and immune dysfunction. Compromised immune function in space manifests as heightened allergic responses, decreased leukocyte counts, impaired leukocyte morphology and activation, diminished macrophage activity, and irregular secretion of interleukins and chemokines.

In the microgravity environment, cells encounter a complex array of stressors, including shear stress induced by blood flow and alterations in gravitational forces. While T-cells primarily reside within tissues, their circulation through the bloodstream and lymphatic system is crucial for reaching target sites. These fluidic environments subject cells to mechanical stresses that necessitate adaptive responses mediated by mechanotransduction. Despite extensive research, a comprehensive understanding of how stress-induced mechanotransduction influences downstream gene expression remains elusive. To elucidate the intricate interplay between bio-fluid dynamics (blood/lymph), T-cell behavior, and subsequent mechanotransduction pathways under microgravity conditions, an integrated computational framework was developed. This framework combines a Computational Fluid Dynamics (CFD) model, which quantifies bio-fluid flow, T-cell deformation, and surface forces under altered gravity, with a modified Python-based Signal Flow Analysis model to investigate signal transduction mechanisms. This integrated approach, termed the MechSigFlow pipeline, simulates gravity-induced mechanotransduction within T-cell signaling networks. The methodology integrates cell surface force data with transcriptomic information and network topology, facilitating the estimation of gravity-induced mechanical signal flow through a signal propagation algorithm. Computational perturbation experiments were conducted on mechano- and gravi-sensitive receptor proteins using the cell surface forces derived from the CFD model. These perturbations revealed significant alterations in the flow of force-induced signals within the network. Statistical verification of these changes indicated modifications in gene expression, which were validated against transcriptomic datasets. The pipeline successfully predicted 63% of network associated common genes, achieving 75.71% accuracy fordownregulated genes and 43.41% for upregulated genes. Data analysis revealed increased force-induced signal flow in pathways associated with the actin cytoskeleton, RAS pathway, and shear stress pathways, which were upregulated. Conversely, signal flow through significant proteins in the Toll-like receptor (TLR), extracellular matrix-receptor (ECM-receptor), nuclear factor kappa B (NFKB), and mitogen-activated protein kinase (MAPK) signaling pathways were downregulated. The MechSigFlow pipeline identified critical motifs for the flow of force-induced signal and amplification within the network, including proteins such as YAP1, STK3, LATS2, PTK2, AKT3, Ca2+, CHUK, PIK3CA, FOS, and SRC. These mechanosensitive proteins operate through a three-layered system: small molecules (e.g., Ca2+), signaling layer proteins (e.g., AKT3, PIK3CA, RAP1, RRAS2, MAPK8, RAC1), and transcription factors (e.g., NFKB1, FOS, YAP1) that ultimately drive gene-level changes. Restoring cellular homeostasis may be achieved by blocking or reversing signal flow or altering the basal activity of small molecules.

Keywords: Microgravity; T-cell; Signalling pathways; Mechanotransduction; Computational modeling.

AMS740 **μBioSat: A platform for microbial analysis in space**

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Understanding the impact of microgravity conditions on biological activity is critical to fully comprehending long term effects on humans. In this context, microbes have garnered significant attention since they serve as model systems that can be quickly used to study specific biological processes. Incorporating such experiments in a modular Lab-on-Chip (LoC) paradigm has gained significant importance in small satellite developments, facilitating the advancement of science in space. Here, we develop a payload designed to perform microgravity experiments on bacterial cultures and study changes in biological activity, all within an independent pico-satellite. The current setup incubates threemillifluidic wells to conduct independent microbiological experiments, which helps us establish statistical significance and in-built redundancy in case of failure. The configuration of wells has two independent experiments and one control well, to determine the reference. These wells are independently regulated and controlled by a fluidic delivery system consisting of a network of valves, pumps, and reservoirs to ensure that the experiment can be carried out without human intervention. Our setup provides a robust method to measure bacterial growth using optical density values. We demonstrate this by using LED-photodiode pairs, latched on to each of the three wells, which continuously monitor the state of the biological species inside the wells. We use this system to study the growth pattern of Sporosarcinapasteurii, a spore-forming bacteria widely explored for its capability to induce calcite precipitation.

The payload's on-board microcontroller controls the logical flow of the experiment and establishes communication with external systems for active telemetric control. We also demonstrate the flight capabilities and launch compatibility of the payload with ISRO's Satellite Launch Vehicle (SLV) series, by subjecting the qualification model to random vibration analysis and harmonic analysis. These analyses validate the structural integrity of the current design and its technology readiness level. This payload represents a complete solution for growing and querying specific microbial species to study their properties under microgravity conditions. Our approach to microfluidic control within a pico satellite facilitates the precise regulation of experimental conditions without human intervention, a first in this scale of satellite experimentation. This work contributes to the development of autonomous, biological and medical research platforms in space, with implications for both fundamental

science and the advancement of space biosciences which can be accessible for researchers at a lower cost.

Keyword: Lab-on-Chip, Millifluidic, Microbiological, Microgravity, Payload, Bacterial growth, MICP (Microbially induced calcite precipitation), Sporosarcinapasteurii, Random vibration analysis, Harmonic Analysis, Pico-satellite.

AMS995 **Microgravity: Novel platform for antibiotic production from streptomycin species**

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Space research opens up areas for the improvement of biotechnology systems, particularly the production of antibiotics. For decades, Streptomyces species are instrumental in pharmaceutical development due to their astounding capability to produce drugs like Streptomycin (Streptomyces griseus), Erythromycin (Streptomyces erythraeus), Tetracycline (Streptomyces aureofaciens), Chloramphenicol (Streptomyces venezuelae), Vancomycin (Streptomyces orientalis) etc.

Streptomyces species are Gram-positive bacteria that have widely been used in the production of a wide array of antibiotics and other secondary metabolites. However, the ability to enhance and utilize space environments in the development of new strategies for the betterment of antibiotic production processes remains underutilized. The following abstract summarizes the use of the space environment as a new platform to study and enhance antibiotic production by Streptomyces species and discusses on the underlying mechanisms and possible advantages of such a process.

Generally, biosynthesis of antibiotics is a very complex metabolic process closely related to the growth of the organism. While these conditions are well understood and optimized on Earth, space offers a new exciting frontier in physical and chemical conditions that can affect microbial growth and metabolism in ways not previously realized. The most interesting ones are microgravity, which can affect fluid dynamics, cellular processes, and microbial interactions while possibly leading to altered metabolic profiles with enhanced production of secondary metabolites.The absence of gravitational forces in space might affect the physical behavior of liquids and gases, influencing, in turn, nutrient and waste exchanges in microbial cultures. Their growth pattern as microbes, expression of genes, and production of metabolites could be affected. Furthermore, space flight can expose cells to higher cosmic radiation than normal, which can lead to genetic mutations and stress responses that may trigger, in turn, the production of new or improved antibiotic compounds. The understanding and harnessing of these effects can leadto some outstanding improvements antibiotics production. Improvement in antibiotic production in space may provide greater yield and establishment of new types of antibiotics to overcome the increasing problem of antibiotic resistance.

To understand these possibilities, a specialized, space-condition bioreactor platform would be needed. Such a platform would require accommodation for unique aspects brought on by microgravity, like having a prepared method for nutrient delivery and waste removal. The experimental designs would involve growth in space, while monitoring keenly the growth parameters, yields of antibiotics, and metabolic changes in Streptomyces species. Such production and characterization of antibiotics in space would be analyzed using HPLC, mass spectrometry, and molecular biology techniques. The knowledge so derived from the studies of microbes in space could provide important information on basic biological functions, which would have a bearing on the planning for space missions as well as application in the terrestrial environment.Yet, there are several challenges that must be overcome, including the cost associated with space missions, designing and operating bioreactor systems in space, and special equipment. This means that future research will play a key role in optimizing these procedures and translating the findings into practical reality.

Lastly, the microbial species that have been developed on Earth to use in the field of antibiotics production include streptomycin, erythromycin, penicillin, vancomycin, and tetracycline and until now, several microorganism species—like Bacillus, Clostridium, Cyanobacterium, Micrococcus, and others—have been found and studied in space environments, providing crucial insights into how life can survive and behave in such conditions.

In this poster presentation, I will also discuss about case studies of antibiotic production in microgravity conditions, payload designed etc.

Keywords: Microgravity, Streptomycin species, fermentation, antibiotic production, bioreactors

AMS 985 **Microgravity as a platform to enhance drug loading efficiency innanomaterials**

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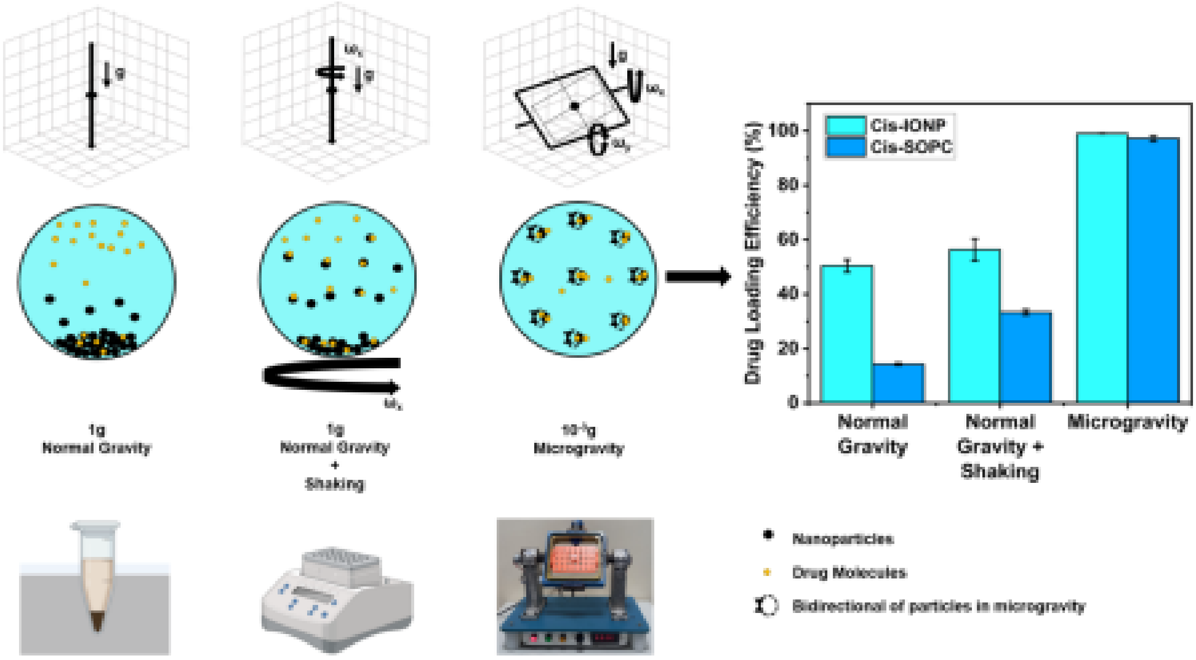
Drug loading in nanoparticles, with their application in nanomedicine, finds potential benefits over free drugs with increased drug bioavailability, reduced side effects, improved targeted delivery, and controlled drug release. However, the current nanomaterial systems, including metallic, polymer, protein, lipids, and other nanoparticles, face severe challenges with poor drug loading efficiency. This limitation can affect the amount of drug that can be incorporated, potentially requiring higher doses or alternative strategies for certain medications. Several studies have been carried out to improve drug loading efficiency in nanomaterials. However, the process is labor-intensive, expensive, time consuming, unscalable, and needs subject expertise, and the surface engineering process differs from material to material. Therefore, there is a need for the development of a common platform to enhance drug-loading efficiency for all the nanomaterials. In our research work, we have explored the potential of microgravity as a novel platform for enhancing drug-loading efficiency in nanomaterials. The drug loading efficiency was found to be increased more than two-fold in iron oxide nanoparticles (from 50.4 ± 2.3 % to 99 ± 0.05 % with sustained drug release for 120 h) and four-fold in liposomes (from 14.28 ± 0.4 % to 97.2 ± 1 % with sustained drug release for 12 h). We also confirmed that the microgravity based drug-loaded nanomaterials exhibited excellent drug release, biocompatibility, and anticancer efficacies against breast cancer (MCF-7) cells. Our findings set the stage for exploring microgravity as a unique platform to enhance drug loading efficiency in nanomaterials, paving the way for innovative developments in drug delivery and space-based pharmaceutical research.



Keywords: Nanoparticles, Drug loading, Microgravity, Random Positioning Machine.

AMS 984 **Nanotechnology for Space Missions**

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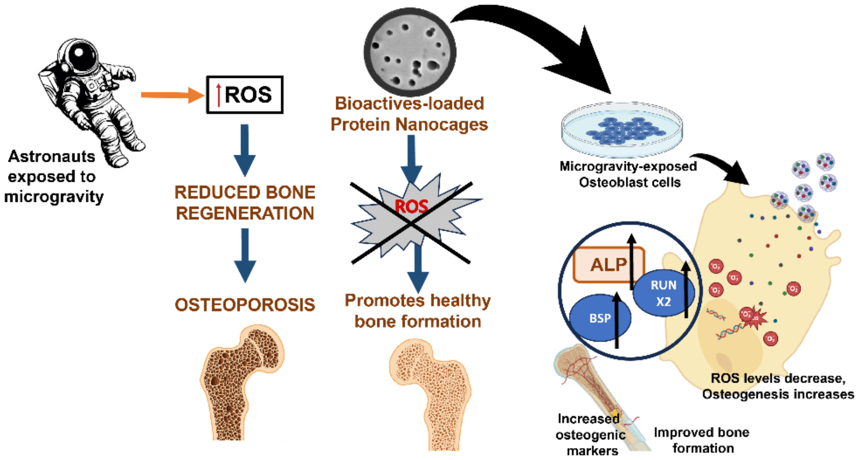
The microgravity conditions of space, along with exposure to cosmic radiation, significantly threaten musculoskeletal health, especially bone density. The mechanisms driving bone loss in space and their connection to oxidative stress at the cellular level are still under research for better understanding. Current treatments aimed at reversing microgravity-induced bone loss often have limited effectiveness and undesirable metabolic side effects. This research explores how simulated microgravity (SMG) influences the production of reactive oxygen species (ROS) and its harmful effects on osteoblasts, leading to cytoskeletal damage and the downregulation of osteogenic genes. To tackle these challenges, we engineered novel protein-zein nanocages that encapsulate a chimeric non-enzymatic antioxidant cocktail (ZNAC), which consists of ascorbic acid, resveratrol, luteolin, coenzyme Q, and glutathione. These nanocages, around 200 nm in diameter, exhibit remarkable stability, biocompatibility, and superior antioxidant capabilities compared to traditional free drug formulations. We evaluated the effectiveness of ZNAC under SMG conditions using MC3T3 pre-osteoblasts/MG63 osteoblasts. Our results demonstrate that ZNAC significantly lowers SMG-induced ROS levels, maintains cytoskeletal integrity in osteoblasts, and markedly increases alkaline phosphatase (ALP) activity alongside the expression of crucial osteogenic genes such as RUNX2 and Col1A1. These findings suggest that ZNAC could be a valuable candidate for promoting bone regeneration in microgravity environments. By reducing oxidative stress and stimulating osteogenic activity, ZNAC may play an essential role in preserving astronaut bone health during prolonged space missions. Furthermore, the antioxidant properties of ZNAC could also present therapeutic opportunities for treating osteoporosis on Earth. This study emphasizes the necessity for innovative approaches to address osteoporosis development in space while offering insights into potential applications for enhancing overall bone health.



Keywords: Nanotherapeutics; Microgravity; Oxidative Stress; Osteoporosis.

Venue :Auditorium

Session 6A: Industry

Dec-04

AMS051 **Agnikul's Agnibaan Sorted: Enabling Microgravity Research with Suborbital Launch Vehicles**

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This paper presents a detailed exploration of a suborbital liquid-propelled controllable launch vehicle (CLV) to serve as a microgravity test platform. The need for efficient, cost-effective solutions in microgravity research has grown in recent years, driven by advancements in fields such as materials science, biological research, fluid dynamics, and combustion studies. Conventional microgravity platforms—such as drop towers, parabolic flight aircraft, sounding rockets, and orbital facilities—each present unique limitations. Drop towers and parabolic flights offer only brief intervals of microgravity, while sounding rockets offer minimal to no control over ascent loads, and orbital facilities are costly and come with significant logistical challenges. Suborbital CLVs, particularly those utilizing liquid rocket propulsion, can be an innovative alternative capable of bridging this gap, offering controlled, repeatable, and extended periods of microgravity in a reusable format.

The primary focus of this paper is the performance analysis of suborbital CLVs being developed by Agnikul, optimized for microgravity applications. The vehicles developed by Agnikul are semi-cryogenic propelled, controlled launch vehicles particularly suitable for this purpose, offering high specific impulse, throttling capability, and precise control over thrust profiles. By fine-tuning the thrust profiles, the propulsion system can deliver a smooth ascent with controlled acceleration, allowing for the careful management of forces that might otherwise disturb sensitive payloads. Additionally, the vehicle is equipped with advanced thrust vector controls and onboard thrusters, enabling active stabilization and trajectory corrections to enhance the quality and duration of the microgravity environment.

The recent testing of Agnikul's Agnibaan SOrTeD vehicle has demonstrated the potential of semi-cryogenic propulsion systems in delivering controlled suborbital flights with precision and reliability. Building on these advancements, the development of a vehicle designed to serve as a dedicated microgravity test platform is a natural extension of Agnikul's capabilities. By taking advantage of the proven performance of Agnibaan SOrTeD, Agnikul aims to provide extended, high-quality microgravity conditions for a range of scientific applications. With enhancements in the propulsion system, and advanced thrust vector

control, Agnikul's vehicles are poised to offer researchers a versatile, cost-effective, and reusable platform for conducting microgravity experiments. The successful integration of these features will not only improve the accessibility of microgravity research but also contribute to the growing demand for innovative testing solutions across industries such as aerospace, space biology, and materials science.

In conclusion, suborbital, liquid-propelled CLVs represent a promising addition to the array of available microgravity research platforms. By offering an affordable, accessible, and customizable option, these vehicles can meet the evolving demands of scientific research and commercial testing. This study underscores the potential of suborbital CLVs to democratize access to microgravity environments and to enable a new era of discovery in a variety of scientific disciplines.

Keywords: Controllable Launch Vehicle; Agnibaan SOrTeD; Reusability; Sub-orbital Microgravity platforms.

AMS052 **Microgravity experiments – a potential use case for the eVTOL aircrafts**

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Urban Air Mobility (UAM) in general, means commuting within the city or in between cities bypassing all the road traffic to a given destination in a much shorter time. Air ambulances are a primitive and crude version of UAM. The flagship product of the ePlane Company is the e200. The e200 is an all composite 3-seater aircraft consisting of a pilot and two passengers. The e200 is an all-electric aircraft with a hybrid mode of operation consisting of Vertical Take Off and Landing (VTOL) and fixed wing modes. It falls under the Lift plus cruise variant of electric VTOL (eVTOL). This means that the VTOL and the forward flight are achieved using separate propulsion units. The e200's power plant primarily consists of state-of-the-art brushless electric motors powered by advanced Lithium Ion (Li-ion) batteries. The aircraft is designed to fly at lower speeds, typically in the range of 160 kmph -180 kmph. The e200 is the most compact aircraft in its category and yet capable of low-speed flights. The e200 has the capability to make multiple hops in a single charge of the battery and can also provide a long range in a single flight too. The Unmanned Aerial Vehicles (UAV) developed by the ePlane Company are the e50 and the e100; the numbers conveying the maximum payload carrying capability of the UAVs. Both UAVs are well covered under the drone rules laid down by the Directorate General of Civil Aviation (DGCA). The UAVs, which are autonomous, can be utilized to perform the conventional parabolic path to simulate the microgravity conditions much more easily compared to the manually piloted flights. Robotic experiments can be done in unmanned flights much more cost effectively and in a compact manner. In addition, eVTOL aircrafts do not demand any kind of infrastructure for Take Off and Landing which could serve as a significant cost saving factor for the scientific community. The VTOL capability can also afford us to simulate lunar, Martian and other planetary g levels less than earth's gravity as well.

Keywords: UAM; VTOL; eVTOL; UAV; Parabolic Flight Path.

AMS852 **New Space Industries for 'Untact' Society**

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We have seen the first wave of new space industries in rocket launches and satellite services such as SpaceX, Rocket Lab and Planet Labs. Compared to traditional space missions mostly driven by government funding, new space industries with significant cost reductions arose from private funding such as venture capitals and IPOs. Nevertheless, their rapid growth has raised challenges in international regulations at many levels including space debris, planetary protection and the legal frame work for space utilization. Eventually we need to be prepared both legally and industrially for interplanetary civilization. In this regard, we are expecting the second wave of new space industries, which will enable space habitation and manufacturing for the eventual space colonization. However, we have not gained enough interests and concerns from the terrestrial industries and governments.

The concept of 'untact' society was originally proposed to promote the digital connection with increasing contactless consumer market trends. It became very popular during COVID-19 pandemic period with physical distancing enabled by digital technology such as internet, IoT and robotic automation. The need for technologies that enable remote work and telehealth had never been greater. Unmanned space missions have been the driving force for technology innovation for robotic automation and truly remote work over space. Long-term manned space missions like lunar and Martian expeditions may demand advanced medical technology more than current telemedicine. If we reflect on the success story of the first wave of new space industries, the proper alignment of advanced consumer technology developed from terrestrial industries and profitable space industry targeted for space utilization must be the focal point of due diligence. However, the hindsight of the first-wave new space industries should be implemented well before the realization of space colonization such as lunar and Martian habitats. It will be essential to prevent the potential pollution and exhaustion of international space resources as humanity expands its activities beyond Earth. Given the increasing interest in space exploration and commercial ventures, the existing international protocol such as COSPAR planetary protection and UN Outer Space Treaty may need to be amended. Moreover, the technological and political approach to benefit humanity both beyond Earth and here on Earth should be taken to address global challenges and improve the quality of life, leveraging the advancement in space exploration.

In conclusion, this talk will discuss how technologies for untact society must be aligned to enable the second wave of new space industries. Space & microgravity industries have long been at the forefront of innovation, pushing the boundaries of what is possible in harsh and remote environments. If we admit the interconnectedness and the finite nature of our own planet, Earth itself is a spaceship or a space station. Well-aligned biotech companies with strong digital technology may provide the solutions for food and healthcare problems, enabling circular and sustainable economy both on Earth and in space. Hence we suggest that the global challenges such as aging population and global warming be also reframed and solved in this new space industries and untact society perspective.

Keywords: untact; digital connection; physical distancing; space habitation; circular economy; Committee on Space Research (COSPAR)

AMS054 **A LEO-based Recoverable Microgravity Platform and Earth Re-entry Logistics Service**

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Inbound Aerospace, IITM Incubation Cell, D Block, IITM Research Park, Chennai, India

The space industry is expected to reach $1 trillion in annual revenue by 2040, fuelled by the emergence of private players and the decreasing cost of launching to Low Earth Orbit, unlocking more services from orbit. The space industry is going through a transition phase leading to extensive commercialisation of the Low Earth Orbit. The microgravity gold rush for life and material science advancements fuels this. Space offers a unique environment of vacuum and microgravity to create many products that are important to life on Earth but would be difficult or impossible to produce on Earth. New classes of drugs and novel materials developed in space could have a transformational impact in areas as diverse as pharmaceuticals and microelectronics.

Several companies are progressing towards small-scale production of materials formulated in space, including on free-flying platforms designed for in-space R&D and manufacturing. The return to Earth will be the critical enabler in unlocking the space sector growth. As low-cost launches have reshaped the space sector over the last decade, the advent of low-cost, frequent return-to-Earth capabilities is expected to have a similar impact over the next decade.

Inbound Aerospace aims to lead and strategically position itself by maturing these capabilities to capture the market. Inbound Aerospace is developing a Low Earth Orbit-based unmanned recoverable microgravity spacecraft platform which acts as an Earth re-entry logistics service for customers to conduct in-orbit testing & technology demonstrations, microgravity research, or in-space manufacturing of products that have use cases back on Earth. This will allow customers to take advantage of the unique environment of space to accelerate their technology development timelines or to manufacture innovative products in space and return them to improve life on Earth. The talk will highlight the spacecraft that Inbound Aerospace is developing.

Keywords: Recoverable Spacecraft; Microgravity Research; Re-entry Logistics; In-Space Manufacturing.

AMS056 **On Orbit Manufacturing of Antennas by Printed Electronics**

Dr. Ram Prasad Gandhiraman

Space Foundry Inc.

Space Foundry is developing plasma jet based direct write printing technology to enable next generation of printed electronics products. State of the art inkjet and aerosol jet techniques require number of process steps including pre-processing of ink, pre-treatment of substrate, printing and curing and also relies heavily on high quality inks. Plasma jet printing allows integration of multi-material and multi-layered printing in one platform using an in-house developed ink that is stable with long shelf life. Our printing technology in combination with in house ink eliminates the dependency on ink supply chain and reduces the number of process steps and additional hardware for pre-treatment and post treatment. In combination with additive manufacturing, plasma jet printing can be used to print passive electronics.

Funded by NASA SBIR (phase 1 through 3) and NASA flight opportunities program, we demonstrated printing of a functioning antenna in microgravity using parabolic flight. We are currently working on demonstrating the printer in low earth orbit and the goal is to have continued on orbit presence.

Venue: IITRP

Industrial Visit

Dec-05

	Time
IITM **Research** Park & IITM Microgravity Drop Tower	09:00-13:00

Chennai

Local Tour

Dec-06

		Time
*	Mahabalipuram	09:00-13:00

**due to the weather conditions may change*