Kalpana Chawla Space Academy

SPACE SPECTRUM

e-newsletter

February

2025

Foreword

Greetings to everyone reading the KCSA Space Spectrum,

It brings us immense pleasure to announce the launch of the first edition of KCSA's e-newsletter in November 2024. We aim to present a collection of scientific articles that explore diverse dimensions of science, technology, and space science.

**The views expressed by the authors in their articles are solely their own.*

Aim

To theorize, sight see, augment knowledge baskets with literary work on science, technology and space science in form of e-newsletter among budding scientists, parents, researchers, academicians and industrial practitioners.

Purpose

- To provide engaging content that educates readers about current space science topics, discoveries, and innovations, fostering a greater understanding of the universe.

- To inspire and equip readers for careers in space science, helping them navigate educational and professional pathways.

- To foster connections among KCSA members and the wider community by sharing stories, events, and achievements, while inspiring engagement in space-related activities and discussions.

Space Spectrum

The KCSA e-newsletter, Space Spectrum, serves as a vibrant hub for all things related to space science. Designed to educate and inspire, it delivers the latest updates, discoveries, and research from the cosmos. Each issue offers in-depth articles that break down complex topics into digestible insights, making the wonders of the universe accessible to everyone.

Space Spectrum fosters a strong sense of community among KCSA members, spotlighting individual achievements and collaborative projects. Readers can share their stories, engage in discussions, and contribute their own articles, enhancing the collective knowledge and experience.

In addition to educational content, the newsletter highlights upcoming events, from workshops and lectures to hands-on activities. Members are encouraged to participate, fostering connections and promoting a culture of learning and exploration.

The newsletter also features a dedicated section for career opportunities, offering guidance for aspiring space scientists. With profiles of professionals in the field, readers gain valuable insights into potential career paths and networking tips.

Overall, Space Spectrum is not just an e-newsletter; it's a dynamic platform that nurtures curiosity among young minds, builds community, and celebrates the endless possibilities of space science. Join us in exploring the universe, one edition at a time!

Editorial Desk

Welcome to the inaugural edition of Space Spectrum, KCSA's e-newsletter created to connect our community with the fascinating world of space science. Our mission is to inform, engage, and inspire by sharing the latest advancements in science, technology, and space exploration.

Each edition will cover a wide range of topics, from groundbreaking discoveries to insights from leading scientists, simplifying complex ideas for everyone to enjoy. We believe that exploring the universe should be accessible to all, and this newsletter is designed to ignite that curiosity.

Space Spectrum is also a platform for our community. We encourage you to share your experiences, projects, and questions, fostering vibrant discussions among members. Your contributions are vital to shaping our content.

Additionally, we'll feature updates on events, workshops, and career opportunities to keep you connected and informed. This newsletter aims to be a hub for growth, learning, and collaboration.

Join us in celebrating the wonders of space science and the remarkable efforts within KCSA. Together, let's explore, learn, and inspire the next generation of space enthusiasts.

Thank you for being part of our journey. We look forward to your insights and contributions in future editions of Space Spectrum.
Happy reading!

Editor
Dr. Pushpendu Rakshit
Program Director, KCSA

Why do Salmon's not get lost in the ocean?

Dr. Khusala Rajendran
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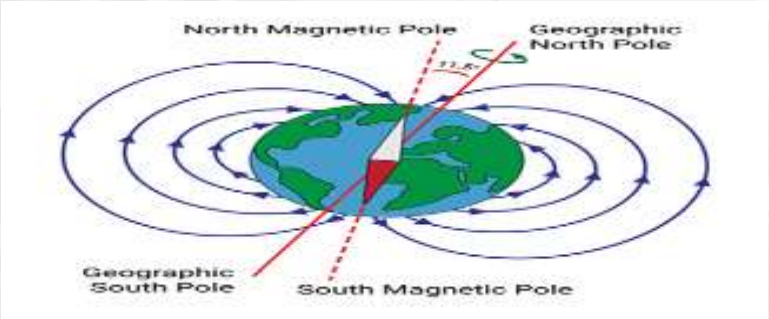
A curious student once asked the teacher about how the Pacific salmon manage to swim all the way to their natural freshwater hatcheries in Alaska, without getting lost. How do they find which way is north? The answer lies in the way the magnetic field of the earth, or the myriad ways in which the geomagnetic field influences many aspects of life. A diverse range of organisms, including the migratory birds, have evolved ingenious and intricate mechanisms to detect the magnetic field which they use for orientation and locomotion. In other words, their bodies have an ingrained micro magnet that detects the magnetic field that helps them navigate. Any student with a basic understanding of physics knows that Earth's magnetic field, or the geomagnetic field, is generated in our planet's interior and extends out into space, creating a region known as the magnetosphere. How it has originated is a complex story, which we would learn as we learn more about the evolution of the earth. But we know that without the magnetic field, which shields us all from the cosmic radiations, life would not flourish on the Earth. Let us visualize the magnetic field as a large bar magnet inside the earth, roughly aligned with the Earth's axis, with their ends located about 10 degrees away from the geographic North and South poles. Earth's invisible magnetic field lines travel in a closed, continuous loop running in the north- south direction and nearly vertical at each magnetic pole. Thus, the earth has two sets of poles, geographic pole and magnetic poles and if one follows the magnetic field lines, using a compass, it is easy to get close to the geographic north. Like we use the compass, the Salmon uses the built it micro magnet in their bodies to travel along the magnetic field lines, to head north! The Salmon story tells us that learning about the earth is also about the way its organisms adapt. It is about combining physics, chemistry, geology, mathematics and more to unravel the mysteries of things that happen around us. Quietly, but in unimaginable ways!



Future of Hybrid Rocket For Space Applications

Dr. Rajeev Kumar

Assistant Professor Department of Space Engineering and Rocketry,
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Rocket propulsion is completely different from the other propulsion system, as it is designed to travel beyond atmosphere. It carries its own fuel and oxidizer and do not depend on external energy sources for their propulsive power. It is classified based on the sources of energy and accordingly names such as chemical, electrical, nuclear rocket propulsion etc. has been given. Among these, chemical rocket utilizes the chemicals such as Hydroxyl Terminated Polybutadiene (HTPB), Liquid Oxygen (LOX), Paraffin wax, Nitrous oxide etc. for their combustion and generation of thrust. Due to easily availability of these chemicals, they are extensively used. These chemical rockets are further classified as solid, liquid and hybrid rocket system. In solid rocket, fuel and oxidizer is in solid phase while in liquid rocket fuel and oxidizer is in liquid phase. The combination of both, solid and liquid rocket is known as hybrid rocket.

Hybrid rocket has many advantages such as safety compared to the solid rocket engine, can be easily throttled depending on the requirements. Since the fuel and oxidizer are stored separately and its combustion mechanism is dependent on the oxidizer mass flux instead on the chamber pressure, the explosion hazards are lower. In hybrid rocket only oxidizer requires to be injected into the combustion chamber, thus piping requirements is only for oxidizer injection into the combustion chamber. It eliminates the complex piping arrangements as observed in liquid rocket engine. Even its specific impulse is higher than solid rocket engine and some cases close to the liquid rocket engine.

Due to these benefits, in the near future, it is being proposed that hybrid rocket could be utilized by the military application as backpack system, where they can easily climb any steep area within a fraction of second and also it would be difficult for the enemy to be traceable. Apart from this, it could also be used as tourism vehicle, where people could be taken to space up to certain altitude and can comeback safely. Apart from it, it can be used in strategic missiles as well as launch vehicle due to its higher manoeuvrability, Throttleability and controllability. Also, currently, rocket technology is moving towards the green propulsion. In this aspect also, hybrid rocket is superior as the fuel generally used to give non-toxic exhaust.

Green Propellant: Future of Chemical Propulsion

Dr. Shelly Biswas

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Chemical rocket propellants are extensively utilized for launch vehicles, missiles, spacecraft, and satellites and other propulsive devices. A composite solid propellant contains oxidizer, fuel binder, metal fuels, plasticizer, cross-linking or bonding agent, curing agent, catalysts, modifiers, and other components. The oxidizer ammonium perchlorate (AP) provides excellent performance in terms combustion and ballistic properties as compared to other oxidizers. But, it has a major drawback that it emits hazardous gases such as hydrogen chloride (HCl) gas into the environment during the combustion process. This emission leads to various environmental consequences, including the reduction of ozone in the stratosphere, the occurrence of acid rain, the acceleration of global warming, and negative impacts on human well-being. Thus, the need of the hour is to develop environmentally friendly ("green") propellants that contribute to developing non-toxic propellants to minimize air pollution produced by rocket launches. These propellants are typically simpler and safer to use than traditional propellants, and they are expected to save money on propellant transportation and storage. Much research has gone into developing environmentally friendly propellants that contribute to developing non-toxic propellants to minimize air pollution produced by rocket launches. Three techniques are available for the reduction of HCl in the exhaust of composite rocket propellants such as using non-chlorine oxidizers, scavenging propellants, and neutralization method. The use of non-chlorine oxidizers such as Ammonium Nitrate (AN), ammonium dinitramide (ADN), Hydroxyl ammonium nitrate (HAN), Potassium dinitramide (KDN) can provide environmental benefits by producing less hazardous combustion products and reduced smoke, making it preferable for applications requiring minimal environmental impact and visual detection. Additionally, its compatibility with a wide range of fuels and binders, alongside its relatively safe handling characteristics, makes it a versatile choice for diverse propulsion needs. Another methods is using sodium nitrate as a scavenging propellant. The third method uses metals and bi-metals as neutralizing components to reduce the chloride exhaust. These propellants give higher density specific impulse; higher energy output and low exhaust emissions. Thus, green propellants are becoming an integral part of future chemical propulsion systems.

The Role of AI in Space Exploration

Mr. Shadab Shaikh

Specialist in HRMS, Aviation, Logistics, E-commerce, Banking, Online Bidding, Chat Software, and AI

Artificial Intelligence (AI) is revolutionizing space exploration through autonomous decision-making, enhanced mission planning, and the analysis of extensive data sets. As we explore the universe, artificial intelligence is demonstrating its transformative potential in addressing the intricacies of space flight and scientific exploration.

AI-Powered Autonomous Spacecraft

Artificial intelligence is essential for facilitating autonomous spaceship operations, particularly in deep-space missions when communication lags with Earth might be considerable. The Mars rovers developed by NASA, including Perseverance, employ AI-driven navigation algorithms to chart topography, circumvent barriers, and execute real-time choices autonomously. Likewise, autonomous space probes, such as Voyager and New Horizons, utilize AI for onboard diagnostics, trajectory adjustments, and optimal data transmission.

Enhancing Space Mission Planning

Algorithms powered by artificial intelligence enhance mission planning through the analysis of extensive datasets and result prediction. Artificial Intelligence assists space agencies such as NASA, ESA, and ISRO in:

Trajectory Optimization - Artificial Intelligence determines optimal flight trajectories, minimizing fuel usage and enhancing mission effectiveness.

Resource Management - Artificial Intelligence enhances energy efficiency in satellites and spacecraft, hence extending their operational longevity.

Space Traffic Management — Artificial Intelligence assists in monitoring and averting satellite collisions in Earth's more congested orbit.

AI in Data Processing and Analysis

Space exploration produces vast quantities of data that require effective analysis. AI-driven systems facilitate:

Astronomical Discoveries - Artificial Intelligence assists researchers in identifying exoplanets, classifying galaxies, and detecting abnormalities in space telescope imagery.

Forecasting Space Weather - Artificial intelligence algorithms evaluate solar activity to predict space weather, safeguarding satellites and astronauts from solar storms.

Image Processing - Artificial Intelligence enhances and analyses photos from observatories such as the James Webb Space Telescope, revealing subtleties that may elude human perception.

AI in Space Robotics

Artificial intelligence improves robotic devices that support humans in space. The Canadarm2 and NASA's Robonaut utilize artificial intelligence to execute intricate operations aboard the International Space Station (ISS). Upcoming missions will include AI-driven robotic helpers, like NASA's Astrobee, to aid astronauts with repairs, data acquisition, and logistical tasks.

The Future of AI in Space

Artificial intelligence will be integral to the next space missions, encompassing:

Autonomous AI Systems — AI-operated spaceship capable of independent decision-making during interstellar journeys.

Swarm Robotics — A consortium of AI-driven robots collaborating for planetary exploration and asteroid extraction.

AI-Enhanced Colonization — AI will facilitate habitat construction and resource management for communities on the Moon and Mars.

AI is not only augmenting space exploration; it is redefining humanity's future existence in space. AI is enhancing the efficiency, cost-effectiveness, and reach of missions through autonomous spacecraft and intelligent data processing.

Rocket In our preparations for deep-space exploration, artificial intelligence will serve as our most significant friend in navigating the unknown.

SpaceX and the Future of Mars: Will We Colonize the Red Planet?

Mr. Shubham Jadav

Specialist in Hydrology, GIS, geoinformatics, and software development

In recent years, the prospect of interplanetary colonization has transitioned from the realm of science fiction into a subject of rigorous scientific and engineering inquiry. Spearheaded by private aerospace companies like SpaceX, the ambition to establish a sustainable human presence on Mars is driving unprecedented technological innovations and prompting serious consideration of the Red Planet's potential as a future habitat. SpaceX, under the leadership of Elon Musk, has been at the forefront of developing technologies critical for Mars colonization. The company's Starship spacecraft, designed for deep-space missions, represents a significant leap in rocket reusability and payload capacity. Its development embodies a strategic integration of advanced materials science, propulsion engineering, and automated control systems—all essential for reliable interplanetary travel. The underlying technological paradigm emphasizes cost reduction and increased frequency of launches, both of which are necessary to support the long-term objective of building a self-sustaining Martian colony. A key scientific challenge in Mars colonization is the planet's inhospitable environment. The thin atmosphere, primarily composed of carbon dioxide, coupled with extreme temperature variations and high radiation levels, necessitates robust life-support systems and innovative habitat designs. Researchers are exploring various in-situ resource utilization (ISRU) methods to convert Martian resources into water, oxygen, and fuel, which could mitigate the logistical challenges of transporting supplies from Earth. SpaceX's mission planning integrates these considerations, proposing that early missions serve not only as exploratory endeavors but also as platforms for testing critical technologies in resource extraction and energy management.

Furthermore, the pursuit of Martian colonization is driving interdisciplinary research that spans astrobiology, planetary geology, and human physiology. Scientists are investigating the long-term effects of reduced gravity on human health and developing countermeasures to prevent bone and muscle degradation. These studies are essential for ensuring that future colonists can thrive in an environment vastly different from Earth. In conclusion, while the path to colonizing Mars is fraught with formidable scientific and engineering challenges, the work spearheaded by SpaceX is laying the groundwork for a transformative era in human exploration. The convergence of innovative propulsion technology, sustainable life-support systems, and comprehensive scientific research is progressively turning the visionary prospect of Martian colonization into a tangible objective. As these developments continue to evolve, the Red Planet may soon transition from a distant world to an extension of human civilization.

Sunita Williams' Return to Earth: A Historic Space Journey

Dr. Pushpendu Rakshit
Program Director
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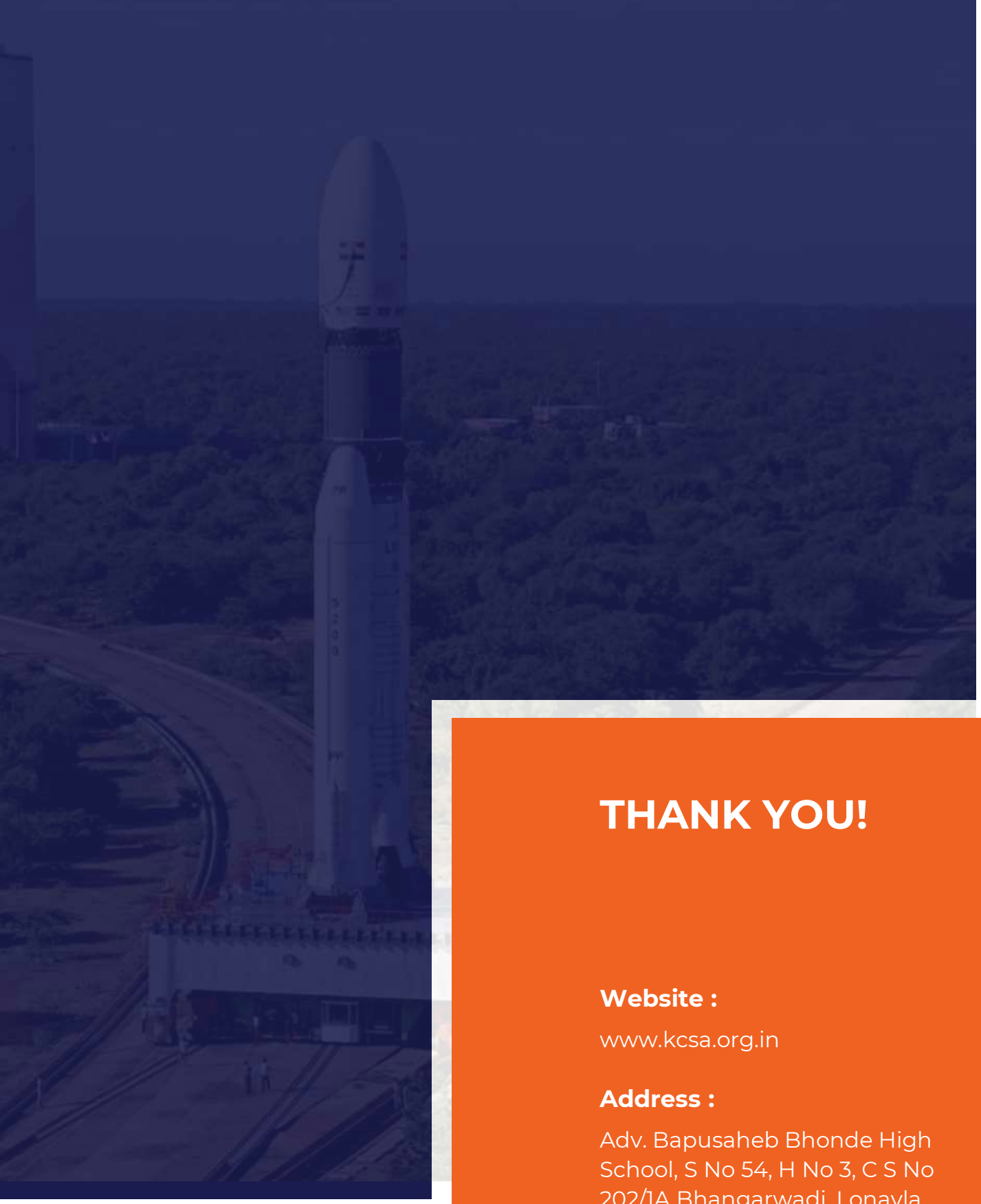
On March 18, 2025, NASA astronaut Sunita "Suni" Williams, along with fellow astronaut Barry "Butch" Wilmore, returned to Earth after an extended mission aboard the International Space Station (ISS). Their journey, which began on June 5, 2024, was initially planned as a brief test of Boeing's Starliner spacecraft. However, technical issues with the Starliner, including thruster malfunctions and helium leaks, led to a prolonged stay in space lasting 286 days (The Washington Post). The astronauts' return was facilitated by SpaceX's Dragon Freedom capsule, which splashed down off the coast of Florida. Upon landing, they underwent medical evaluations to assess their physical condition after months in microgravity . At KCSA we too feel immensely proud for this historic moment.

Prime Minister Narendra Modi of India welcomed their return, praising their perseverance and resilience. He highlighted their mission as a testament to human spirit and determination .

Now back on Earth, Williams and Wilmore are adjusting to gravity and resuming their lives. Their extended mission has provided valuable insights into the challenges of long-duration spaceflight and the importance of international collaboration in space exploration (Business News).



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