

SPACE EXPLORATION AND PLANETARY SCIENCE

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Abstract. *The article highlights the significant achievements in space exploration, which have provided us with a better understanding of the cosmos. According to research about planetary science, which encompasses the study of celestial objects within and beyond our solar system, are using methods to investigate and to describe them. The article discusses the techniques employed by planetary scientists to study these celestial bodies, including ground-based observatories, the Hubble Space Telescope, lab simulations, and spacecraft exploration. Overall, the article provides an overview of the accomplishments and challenges in space exploration and planetary science.*

Keywords: *celestial objects, solar system, spacecraft exploration, discoveries.*

Introduction

Space exploration and planetary science are fascinating fields that have captivated the imagination of people for generations. Over the years, space exploration has achieved several significant milestones that have inspired generations of people to pursue careers in science and engineering. Planetary science, on the other hand, studies the planets, moons, comets, asteroids, and other celestial objects both inside and outside of our solar system. This article discusses the significant milestones in space exploration, the challenges facing space exploration, the techniques employed by planetary scientists to study celestial bodies, and the significant discoveries made by planetary science.

Space exploration

Investigation, by means of crewed and uncrewed spacecraft, of the reaches of the universe beyond Earth's atmosphere and the use of the information so gained to increase knowledge of the cosmos and benefit humanity. That's how Britannica [1] defines space exploration but let's dive deeper to understand it better. Space exploration is an exciting and fascinating field that has captivated the imagination of people for generations. Since the first satellite was launched into orbit in 1957 [2], space exploration has been an area of significant scientific and technological advancement.

Space exploration has been one of humanity's most remarkable achievements, opening up new frontiers in our understanding of the universe. Over the years, space exploration has achieved several significant milestones that have inspired generations of people to pursue careers in science and engineering.

One of the most notable milestones in space exploration is the first human landing on the moon. The Apollo 11 mission in 1969 was a culmination of years of research, development, and testing, and it demonstrated the potential of human spaceflight. The mission's success inspired further exploration of the moon and other planets in the solar system.

Exploration of Mars [3] has also been a significant focus of space exploration. Several robotic missions have been sent to Mars to gather data and explore the planet's surface, atmosphere, and geology. These missions have provided valuable insights into the planet's potential for supporting life, and the presence of water on the planet has suggested the possibility of past or present habitable environments.

Another significant milestone in space exploration is the launch of the International Space Station (ISS) in 1998 [2]. The ISS has been a platform for scientific research and has provided

opportunities for international cooperation in space exploration. The ISS has been instrumental in advancing our understanding of space and has provided a platform for research in a microgravity environment.

Humans have always been fascinated by the prospect of exploring the wide unknown, which has always captured our imagination. Yet, space organizations must carefully assess the hazards and challenges associated with space exploration before beginning any mission. One of the most significant challenges facing space exploration is the technology required. Developing and maintaining the complex and expensive technologies needed for space exploration is a significant challenge. Space agencies must ensure that their technologies are reliable and safe for use in space. However, progress has been slow in developing new technologies, and many of the key technologies, such as solid or liquid propellants, have not seen any significant improvement in recent years.

Another significant challenge is the financial cost of space exploration [4]. Space programs require significant funding, which is not always guaranteed. Space agencies must balance the costs of space exploration with other priorities, and funding for space programs can be unpredictable. To maintain scientific standards for a given budget, mission concepts must be efficient and cost-effective.

The psychological effects of space exploration on astronauts are also a significant concern. Spending extended periods in space can lead to physical and mental health problems, including muscle atrophy, bone loss, and depression. Space agencies must ensure that their astronauts are mentally and physically prepared for spaceflight and that they receive appropriate support during and after their missions.

Planetary Science

Planetary science is a multidisciplinary field encompassing the investigation of the planets, moons, comets, asteroids, and other celestial objects both inside and outside of our solar system. According to NASA (n.d.) [4], planetary science is the study of planets, moons, and planetary systems to understand their origin, evolution, surface processes, internal structures, atmospheres, and potential for life. To comprehend the genesis, evolution, and present state of celestial objects, this fascinating area integrates a variety of observational techniques, lab models, and spacecraft missions.

Our solar system study is one of the main areas of interest in planetary science. According to Elkins-Tanton (2018) [5], studying planets, moons, comets, and asteroids can reveal information about their physical and chemical components as well as information about how they developed and changed over time. To study these celestial bodies, planetary scientists employ a variety of techniques, such as observational techniques, lab simulations, and spacecraft missions. Although ground-based observatories investigate the atmospheres and surface features of planets and moons, the Hubble Space Telescope [6] takes detailed pictures of planets, moons, and other solar system objects. To explore the physical and chemical characteristics of other planets and moons, scientists simulate their environments in the lab.

Another essential tool for studying planets and other celestial objects is spacecraft exploration. For instance, rovers are used by NASA's Mars Exploration Program (2022) [7] to study the planet's geology, chemistry, and atmospheric conditions. Since it started exploring Mars in 2012, the Curiosity rover has learned a tremendous lot about the planet's surface. Additionally, the NASA Cassini-Huygens mission (due to launch in 2022) [7] analyzed Saturn's Titan moon and collected information on its physical and chemical processes.

Planetary scientists are also very interested in comets and asteroids because they can shed light on the early history of the solar system. As a result of the Rosetta spacecraft's investigation of comet 67P/Churyumov-Gerasimenko (ESA, n.d.) [8], a complex, layered structure was discovered, providing support for the theory that comets contributed to the supply of organic molecules and water to the early Earth.

Our understanding of the solar system and beyond has experienced a significant shift as a result of many important discoveries made by planetary science over the years. For instance, the Mars Exploration Mission (2022) of NASA [9] has revealed that water is present in liquid form on Mars' surface and subsurface, increasing the possibility of life there. The NASA-led Cassini mission [7],

which will launch in 2022, shed light on Titan, Saturn's moon, and its physical and chemical processes.

Last but not least, the 2021 launch of the James Webb Space Telescope (NASA, n.d.) [10] will be critical to the advancement of planetary research. It will be able to observe some of the oldest and most distant objects in the universe, giving us a better understanding of the beginnings of the universe's evolution. Also, the telescope will look into exoplanet atmospheres and potentially habitable settings.

All things considered, planetary science is a dynamic discipline that consistently produces ground-breaking findings by utilizing a variety of methods and approaches. These new findings are extending our knowledge of the cosmos and testing it.

Future of space exploration and planetary science

The future of space exploration and planetary science holds immense promise and excitement as humanity continues to push the boundaries of our understanding of the universe. With new technologies and advancements in science, we are on the cusp of unprecedented breakthroughs in our exploration of the cosmos. From planned missions to Mars and the Moon, to the search for habitable exoplanets and the study of black holes, the possibilities for discovery and innovation are endless. The pursuit of space exploration and planetary science not only expands our knowledge of the universe but also inspires and motivates the next generation of scientists and engineers to push the limits of what is possible. The future of space exploration and planetary science is sure to be filled with groundbreaking discoveries and fascinating new insights into the mysteries of the universe.

Considering the ongoing and planned missions in space exploration and planetary science, it is clear that the future of this field is extremely promising. The current missions, such as the Mars 2020 [11] Perseverance rover and the Lunar Reconnaissance Orbiter, have already yielded significant scientific discoveries, and the planned missions, such as NASA's Artemis program and the Europa Clipper mission, have the potential to provide even more groundbreaking insights into our universe.

The upcoming Mars Sample Return mission, which aims to bring Martian rock and soil samples back to Earth, could revolutionize our understanding of the red planet and pave the way for future human exploration. Similarly, the Artemis program's [12] goal of landing humans on the Moon and establishing a sustainable lunar presence is an exciting step towards further exploration and colonization of our solar system.

Advancements in technology have played a crucial role in the ongoing and planned missions in space exploration and planetary science. For instance, the development of more advanced propulsion systems has enabled spacecraft to travel farther and faster than ever before, allowing us to explore deeper into our solar system and beyond. The use of robotics and autonomous systems has also enabled us to conduct complex operations in space, such as the Mars 2020 Perseverance rover's sample collection and caching capabilities.

Furthermore, the development of new scientific instruments has allowed us to gather more detailed data about our universe, from the magnetic fields of Jupiter to the composition of distant exoplanets. Advancements in communication technology have also enabled us to transmit data and images from space more efficiently, allowing us to analyze and interpret scientific data in near real-time. These technological advancements have allowed us to make significant scientific discoveries and will continue to play a crucial role in the future of space exploration and planetary science.

International cooperation is another crucial aspect of the ongoing and planned missions in space exploration and planetary science. Many of the missions, such as the International Space Station and the Mars 2020 Perseverance rover [13], are the result of collaboration between multiple countries, bringing together a diverse range of expertise and resources. International cooperation allows for the sharing of scientific data and resources, allowing researchers around the world to access and analyze data from space missions. This collaboration has enabled significant scientific discoveries, such as the detection of gravitational waves, which was a result of the collaboration between the Laser Interferometer Gravitational-Wave Observatory (LIGO) and Virgo collaborations [14].

The upcoming James Webb Space Telescope [10], with its advanced instrumentation, has the potential to detect the earliest galaxies in the universe and study the atmospheres of exoplanets, potentially providing clues to the origins of life in the universe.

Overall, the potential for new discoveries in space exploration and planetary science is vast, and ongoing and planned missions have the potential to provide groundbreaking insights into the mysteries of the universe. These discoveries not only expand our knowledge but also have the potential to inspire and motivate future generations to continue exploring and pushing the boundaries of what is possible in space.

As we continue to explore the universe, we not only expand our knowledge but also inspire and motivate future generations to continue exploring and pushing the boundaries of what is possible in space exploration and planetary science. The future of space exploration and planetary science is bright, and we can expect to see even more exciting discoveries and advancements in the coming years.

Conclusions

Space exploration and planetary science have been critical in advancing our understanding of the universe. The significant milestones in space exploration, including the first human landing on the moon and the launch of the International Space Station, have inspired generations of people to pursue careers in science and engineering. However, significant challenges such as the technology required and the financial cost must be addressed. Planetary science has employed a variety of techniques, such as ground-based observatories, the Hubble Space Telescope, lab simulations, and spacecraft exploration, to study celestial bodies both inside and outside our solar system. The significant discoveries made by planetary science, including the possibility of life on Mars and the discovery of a complex, layered structure in a comet, have shed light on the early history of the solar system. Future space missions, such as the launch of the James Webb Space Telescope, will be critical in advancing our understanding of the universe.

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