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Technical Overview and Prospect of India's First Solar Mission - Aditya L1 Spacecraft

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Abstract: The Aditya-L1 mission represents a significant milestone in solar research, aimed at unlocking the mysteries of our closest star, the Sun. This paper provides an overview of the mission's objectives, scientific instruments, and key findings. By placing a spacecraft in a Lagrangian point L1 orbit, Aditya-L1 offers an unprecedented vantage point for continuous solar observations. The primary scientific goals include studying the Sun's dynamic atmosphere, monitoring solar variability, and enhancing our understanding of space weather and its impact on Earth. The paper discusses the advanced instrumentation onboard, such as the Visible Emission Line Coronagraph (VELC), the Solar Ultraviolet Imaging Telescope (SUIT), and the Aditya Solar Wind Particle Experiment (ASPEX), highlighting their contributions to solar science. Furthermore, this paper presents early results and insights obtained from Aditya-L1's observations, shedding light on solar phenomena, solar eruptions, and their influence on Earth's space environment. The Aditya-L1 mission stands as a testament to international collaboration and technological advancements, poised to reshape our understanding of the Sun and its profound effects on our solar system.

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1. Introduction

Aditya L1 is the first space based observatory class Indian solar mission to study the Sun. The spacecraft is planned to be placed in a halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system, which is about 1.5 million km from the Earth. A satellite placed in the halo orbit around the L1 point has the major advantage of continuously viewing the Sun without any occultation/ eclipse. This will provide a greater advantage of observing the solar activities continuously. The spacecraft carries seven payloads to observe the photosphere, chromosphere, and the outermost layers of the Sun (the corona) using electromagnetic and particle detectors. Using the specialvantage point of L1, four payloads **[1-5]**.

2. A Short Overview of Aditya-L1

Aditya-L1 is India's first dedicated solar mission, designed to study the Sun's corona and solar wind. It carries seven payloads, four of which will directly observe the Sun and the remaining three will conduct in-situ studies of particles and fields at the Lagrange point L1. The Aditya-L1 payloads will provide crucial information to understand: Coronal heating, Coronal mass ejections, Pre-flare and flare activities, Dynamics of space weather, Propagation of particles, and fields in the interplanetary medium. This information will help us to better understand the Sun's behavior and its impact on Earth **[5-12]**.

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3. A Brief on Indian Space Missions

India has a robust space program conducted by the Indian Space Research Organisation (ISRO). Here is a brief overview of some of India's most notable space missions [1-12]:

- ***Aryabhata (1975):*** India's first satellite, Aryabhata, was launched from the Soviet Union. It marked India's entry into space research.
- ***Mangalyaan (2013)***, also known as the Mars Orbiter Mission (MOM), made India the fourth space agency in the world to reach Mars and the first to do so on its maiden attempt.
- ***Chandrayaan-1 (2008)***, India's first lunar mission, made significant discoveries, including evidence of water molecules on the moon's surface.
- ***Chandrayaan-2 (2019)*** aimed to further explore the moon with an orbiter, lander (Vikram), and rover (Pragyan). While the lander failed to make a soft landing, the orbiter continues to study the moon.
- ***Astrosat (2015)***, India's first dedicated multi-wavelength space observatory, has been used for various astronomical observations.
- ***GSAT Series***: The GSAT series comprises a series of communication satellites that have strengthened India's communication infrastructure.
- ***NavIC (2018)***, the Navigation with Indian Constellation, is India's regional satellite-based navigation system, providing accurate positioning information to users in India and the surrounding region.
- ***Cartosat Series***: These Earth-observing satellites have been launched for cartographic, agricultural, and strategic purposes.
- ***GSLV and PSLV***: India has developed reliable launch vehicles like the Geosynchronous Satellite Launch Vehicle (GSLV) and Polar Satellite Launch Vehicle (PSLV), which have been used for both domestic and international satellite launches.
- ***Aditya-L1 (2023)*** aims to study the Sun's outermost layer and its impact on the Earth's climate.

These missions demonstrate India's growing prowess in space exploration, technology, and satellite development.

4. Mission Objectives

The Aditya-L1 mission, led by the Indian Space Research Organisation (ISRO), aims to study the Sun and its outermost layer, the corona. It will achieve this through a suite of seven scientific payloads that will observe the Sun in a variety of wavelengths. The Aditya-L1 mission has the following scientific goals [1-12]:

- ***Study the solar corona:*** Aditya-L1 will investigate the corona's dynamics, structure, and temperature variations. This will help us to better understand the coronal heating problem, which is one of the most fundamental unsolved problems in solar physics.
- ***Understand solar magnetic activity:*** Aditya-L1 will study the Sun's magnetic field and its relationship to solar activities such as sunspots, solar flares, and coronal mass ejections (CMEs). This will help us to better predict space weather events, which can impact Earth's technology and infrastructure.
- ***Characterize the solar wind:*** Aditya-L1 will measure the properties of the solar wind, such as its composition and velocity. This will help us to understand how the solar wind interacts with the Earth's magnetosphere and space weather.
- ***Investigate the Sun-Earth connection:*** Aditya-L1 will study how solar activities and solar wind impact Earth's magnetosphere, ionosphere, and climate. This will help us to better understand the Sun-Earth system and its impact on our planet.

In addition to these scientific goals, Aditya-L1 also has the following practical goals:

- ***Enhance space weather prediction:*** Aditya-L1 will provide data that can be used to improve the prediction of space weather events, such as solar flares and geomagnetic storms. This will help to mitigate the impact of these events on our society.
- ***Complement global solar observations:*** Aditya-L1 will collaborate with other solar observation missions, such as NASA's Parker Solar Probe and the European Space Agency's Solar Orbiter, to provide a more comprehensive understanding of the Sun.

The Aditya-L1 mission is a highly ambitious and scientifically significant mission that will provide new insights into the Sun and its impact on Earth. It is a testament to India's growing prowess in space exploration and research.

5. Scientific Instruments Onboard Aditya-L1

The Aditya-L1 mission carries seven scientific instruments to study the Sun and its outermost layer, the corona. These instruments are designed to capture data and images related to various aspects of the Sun, including its dynamics, structure, composition, and magnetic activity. Here is a brief overview of each instrument **[13-29]**:

- Visible Emission Line Coronagraph (VELC): VELC captures images of the solar corona in visible light with high spatial and temporal resolution. This allows scientists to study the dynamics and structure of the corona in great detail.
- Solar Ultraviolet Imaging Telescope (SUIT): SUIT is an ultraviolet (UV) imaging instrument that observes the Sun's chromosphere and the transition region between the chromosphere and the corona. This provides insights into the Sun's lower atmosphere and its interface with the corona.
- Plasma Analyzer Package for Aditya (PAPA): PAPA measures the properties of ions and electrons in the solar wind. This helps scientists to understand the composition and characteristics of the solar wind as it emanates from the Sun.
- Aditya Solar Wind Particle Experiment (ASPEX): ASPEX is another instrument dedicated to studying the solar wind. It measures the properties of charged particles (ions and electrons) in the solar wind to gain insights into its behavior.
- Multi-Application Solar Telescope for Imaging and Spectroscopy (MASTIS): MASTIS is a solar telescope that provides high-resolution imaging and spectroscopic observations of the Sun. It can capture detailed images of the solar surface and analyze the solar spectrum.
- Coronal Mass Ejection (CME) Detector: The CME detector studies coronal mass ejections, which are massive bursts of solar wind and magnetic fields. Understanding CMEs is important for space weather forecasting.
- Solar Low Energy X-ray Spectrometer (SoLEXS): SoLEXS detects and analyzes X-rays emitted by the Sun. This helps scientists to understand the high-energy processes occurring in the solar corona.

The Aditya-L1 mission is expected to provide new insights into the Sun and its impact on Earth. The scientific instruments onboard the spacecraft are essential for achieving this mission

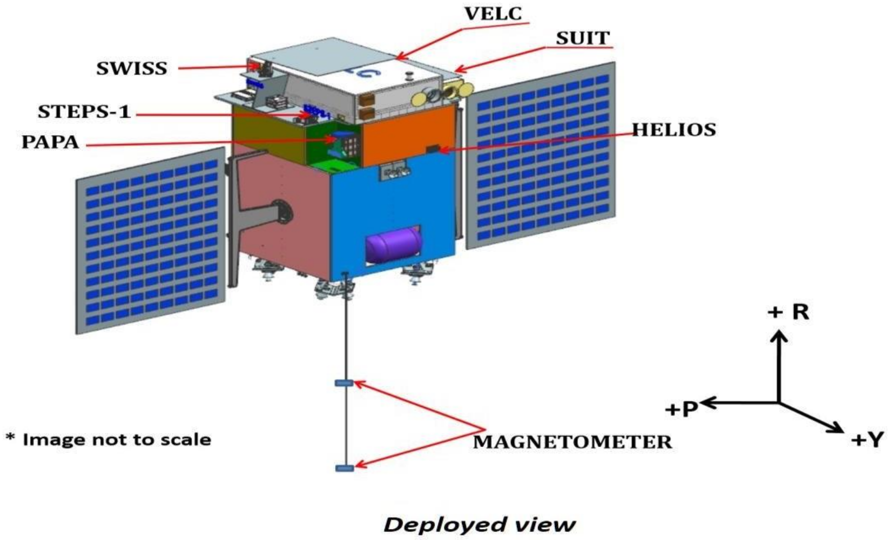

Figure-1 Deployed View of Aditya-L1 Spacecraft with Instruments [Courtesy: ISRO]

6. Scientific and Practical Importance of the Aditya-L1 Mission

The Aditya-L1 mission holds significant scientific and practical importance, with the potential to make several important discoveries in the field of solar and space science **[13-29]**.

- ***Understanding Solar Activity:*** Aditya-L1 will study the Sun's outermost layer, the corona, and its magnetic activity. Discoveries in this area could lead to a better understanding of the processes that drive solar activity, such as solar flares and coronal mass ejections (CMEs). This knowledge is crucial for predicting space weather, which can impact satellites, GPS systems, and power grids on Earth.
- ***Space Weather Prediction:*** One of the primary goals of Aditya-L1 is to improve space weather prediction. Solar flares and CMEs can release large amounts of energy and charged particles into space,

which, when directed towards Earth, can cause geomagnetic storms. These storms can disrupt communication systems, navigation systems, and power grids. Discoveries made by Aditya-L1 could lead to more accurate and timely space weather forecasts, allowing for better preparedness and mitigation efforts.

- ***Solar wind and its Effects:*** Aditya-L1 will study the solar wind, a continuous stream of charged particles emitted by the Sun. Understanding the solar wind's composition, speed, and variations is crucial for comprehending its effects on Earth's magnetosphere and the interaction between the solar wind and our planet.
- ***Advancing Solar Physics:*** The mission will contribute to advancing our understanding of solar physics. Observations from Aditya-L1 could shed light on phenomena like magnetic reconnection, which plays a role in solar flares and CMEs, as well as the dynamics of the solar corona and its temperature variations.
- ***Complementing Global Solar Observations:*** Aditya-L1 will collaborate with other solar observation missions, such as NASA's Parker Solar Probe and the European Space Agency's Solar Orbiter, to provide a more comprehensive view of the Sun. This collaboration enhances our ability to monitor and understand the Sun's behavior and its impact on the solar system.
- ***Solar Science and Space Exploration***: Beyond its impact on Earth's technology and infrastructure, Aditya-L1's discoveries can contribute to broader solar science and our understanding of the Sun's role in the solar system. Additionally, it may provide valuable insights for future space exploration missions, including those headed to the Moon, Mars, and beyond.

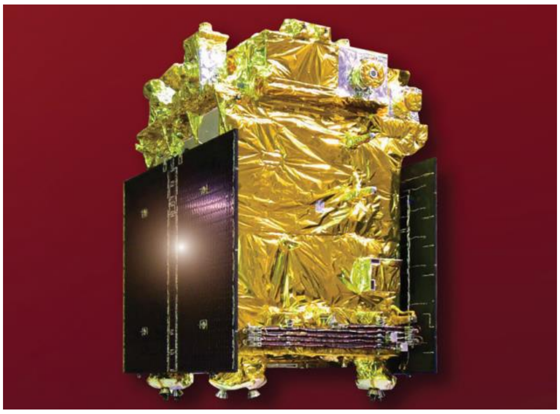

Figure-2 Stowed View of Aditya-L1 Spacecraft [Courtesy: ISRO]

7. Conclusion

Aditya-L1 is a revolutionary satellite for multi-messenger solar physics. Its suite of instruments will perform remote sensing across a broad range of the electromagnetic spectrum and in situ measurements in a wide energy range from the same platform. This will allow Aditya-L1 to make unprecedented observations of the Sun, including: regular measurements of the coronal magnetic field from space, spatially resolved solar spectral irradiance in the near ultraviolet Flares in both soft X-ray and hard X-ray, the dynamics of the inner heliosphere. The combination of remote sensing and in situ measurements, as well as the wide range of wavelengths and energies covered by Aditya-L1's instruments, will make it a powerful tool for studying the Sun and its impact on the solar system.

8. References

[1] Seetha, S., & Megala, S. (2017). Aditya-L1 mission. Current Science, 610-612.

[2] Tripathi, D., Chakrabarty, D., Prasad, B. R., Nandi, A., Ramaprakash, A. N., Shaji, N., & Yadav, V. K. (2022). The Aditya-L1 mission of ISRO. arXiv preprint arXiv:2212.13046.

[3] ISRO. Retrieved from https://www.isro.gov.in/Aditya_L1.html on 28-September-2023.

[4] Sharma, A. K. (2020). Aditya-L1: First Indian Mission to Study the Sun.

[5] Srivastava, D. (2023). IISER Pune professor shares insights on Aditya-L1 mission.

[6] Banerjee, D. (2020, December). Status update on Aditya-L1. In AGU Fall Meeting Abstracts (Vol. 2020, pp. SH031-06).

[7] Tripathi, D. (2016). The Aditya-L1 Mission of Indian Space Research Organization. 41st COSPAR Scientific Assembly, 41, D2-2.

[8] Sundararajan, V. (2018). Space System Architecture of India's Aditya-L1 Mission to study the Sun. In 2018 AIAA SPACE and Astronautics Forum and Exposition (p. 5128).

[9] Seetha, S. (2014). Proposed Aditya-L1 Mission.
[10] Annadurai, M., & Director, I. S. A. C. (2017). Future exploration missions of ISRO. 60th session of the United Nations Committee on peaceful uses of outer space.
[11] Das, T. P., Hasan, M., Megala, S., Kumar, K. P., Girish, V., & Antonita, T. M. (2021). Indian space science missions. Nature Reviews Physics, 3(11), 722-723.
[12] Koros, M. (2023). UK Solar Physics. Institutions.
[13] Prasad, B. R., Banerjee, D., Singh, J., Nagabhushana, S., Kumar, A., Kamath, P. U., ... & Jaiswal, B. (2017). Visible emission line coronagraph on Aditya-L1. Current Science, 613-615.
[14] Mayank, P., Vaidya, B., & Chakrabarty, D. (2022). SWASTi-SW: Space Weather Adaptive Simulation Framework for Solar Wind and Its Relevance to the Aditya-L1 Mission. The Astrophysical Journal Supplement Series, 262(1), 23.
[15] Janardhan, P., Vadawale, S., Bapat, B., Subramanian, K. P., Chakrabarty, D., Kumar, P., ... & Subhalakshmi, K. (2017). Probing the heliosphere using in situ payloads on-board Aditya-L1. Current Science, 620-624.
[16] Goyal, S. K., Kumar, P., Janardhan, P., Vadawale, S. V., Sarkar, A., Shanmugam, M., ... & Bhavsar, R. R. (2018). Aditya solarwind particle experiment (ASPEX) onboard the Aditya-L1 mission. Planetary and Space Science, 163, 42-55.
[17] Raj Kumar, N., Raghavendra Prasad, B., Singh, J., & Venkata, S. (2018). Optical design of visible emission line coronagraph on Indian space solar mission Aditya-L1. Experimental Astronomy, 45, 219-229.
[18] Tripathi, D., Ramaprakash, A. N., Khan, A., Ghosh, A., Chatterjee, S., Banerjee, D., ... & Solanki, S. K. (2022). The Solar Ultraviolet Imaging Telescope onboard Aditya-L1. arXiv preprint arXiv:2204.07732.
[19] Narra, V. S., Budhiraju, V. R., Venkatasubramanian, N., Raha, B., Hegde, B., Uppuluri, R. S., ... & Budihal, R. P. (2023). Performance evaluation of Littrow lens assembly for Visible Emission Line Corongraph (VELC) on board Aditya-L1 mission. Journal of Optics, 1-6.
[20] Kasiviswanathan, S. (2018). Solar Coronal Magnetic Field Studies with Aditya-L1 Mission. 42nd COSPAR Scientific Assembly, 42, E2-3.
[21] Singh, J., Prasad, B. R., Venkata, S., & Kumar, A. (2019). Exploring the outer emission corona spectroscopically by using Visible Emission Line Coronagraph (VELC) on board ADITYA-L1 mission. Advances in Space Research, 64(7), 1455-1464.
[22] Venkata, S., Prasad B, R., & Singh, J. (2022). Spectropolarimetry package for visible emission line coronagraph (VELC) on board Aditya-L1 mission. Experimental Astronomy, 53(1), 71-82.
[23] Narra, V. S., Singh, D., Venkatasubramanian, N., Budhiraju, V. R., Hegde, B., Bhat, N., ... & Budihal, R. P. (2022). Optical metrology on primary mirror of visible emission line coronagraph on board Aditya-L1 mission. Journal of Astronomical Telescopes, Instruments, and Systems, 8(4), 044004-044004.
[24] Venkata, S. N., Prasad, B. R., Nalla, R. K., & Singh, J. (2017). Scatter studies for visible emission line coronagraph on board ADITYA-L1 mission. Journal of Astronomical Telescopes, Instruments, and Systems, 3(1), 014002-014002.
[25] Venkata, S., & Budihal, R. P. (2021). Light scattering due to particulate contamination over the primary mirror of Visible Emission Line Coronagraph on board Aditya-L1 mission. Optical Engineering, 60(7), 074103-074103.
[26] Nagaraju, K., Prasad, B. R., Hegde, B. S., Narra, S. V., Utkarsha, D., Kumar, A., ... & Kumar, V. (2021). Spectropolarimeter on board the Aditya-L1: polarization modulation and demodulation. Applied Optics, 60(26), 8145-8153.
[27] Banerjee, D., Sankarasubramanian, K., & Kumar, A. (2018). Onboard Automated CME Detection Algorithm for the Visible Emission Line Coronagraph on ADITYA-L1.
[28] Chatterjee, S. (2019). Characterizing image quality of solar ultraviolet imaging telescope on board Aditya L1-mission and long-term study of the sun (Doctoral dissertation, Indian Institute of Astrophysics).
[29] Manoharan, P. K., Naidu, A., Joshi, B. C., Roy, J., Kate, G., Pethe, K., ... & Patil, R. A. (2016, March). Low Frequency Radio Experiment (LORE). In IOP Conference Series: Materials Science and Engineering (Vol. 120, No. 1, p. 012014). IOP Publishing.

9. Biography

Sowmya G, a UG Research Scholar at S.J.C. Institute of Technology, Karnataka, displayed a fervent interest in space technology during her internship at Acceleron Aerospace. Her project, "Technical Overview and Prospect of India’s First Solar Mission - Aditya L1 Spacecraft," explored the pioneering Aditya L1 Spacecraft mission, reflecting her dedication to aerospace engineering. With a promising future, Sowmya is poised to make significant contributions to India's space exploration efforts.

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11. Conflict of Interest

The author have no conflict of interest to report.

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