

PARLIAMENT QUESTION: ACHIEVEMENTS OF ADITYA-L1 MISSION

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The scientific objectives of Aditya-L1 are to study the solar wind particles, Solar corona, near UV signatures on the solar disc, as well as the solar magnetic fields (the Interplanetary Magnetic Field – IMF). The position of Aditya-L1 around the Sun-Earth L1 point facilitates continuous view of the Sun, making it a dedicated solar physics observatory.

A few major achievements of Aditya-L1 include:

- Capturing the first-ever spectroscopic signatures of the onset phase of a Coronal Mass Ejection (CME), a phenomenon in which a chunk of the solar plasma material is ejected by the Sun.
- By combining global ground measurements with direct particles and fields observations from Aditya-L1, scientists brought out insights to some of the interesting observations during the intense geomagnetic storms of May and October 2024.
- Aditya-L1 observations also yielded the first comprehensive analysis of photospheric iron fluorescence on the Sun, capturing this phenomenon across 47 massive X-class solar flares during the peak of Solar Cycle 25 in 2024.
- Aditya-L1 captured unprecedented, high-resolution details of powerful solar flares in near-ultraviolet (NUV) wavelengths. Using these observations, Aditya-L1 recorded a first-of-its-kind, highly detailed view of a rare solar plasma ejection in ultraviolet light, expanding our understanding of the localized dynamics of solar eruptive events.

There are several other science results from Aditya-L1. All these results are published in reputed peer reviewed scientific journals.

Aditya-L1 is a solar physics mission, and does not fall under the category of a space weather mission. However, the data from Aditya-L1 facilitate the understanding of the behavior of the Sun in different phases of the solar cycle.

- Combining Aditya-L1 observations with ground-based observations, scientists get an understanding of the Sun-Earth connection, which eventually helps understanding the space weather impacts.
- The experience gained from Aditya-L1 will be useful to move forward to configure space-based systems towards the prediction of the space weather.

Thus, Aditya-L1, despite being a Solar physics mission, is a significant step for India's journey towards having a space weather prediction capability.

The major scientific outcomes of India's recent lunar mission near the Moon's south pole include the following:

- The Chandrayaan-3 mission has, so far, been the only successful mission to the polar region of the Moon.

- The ChaSTE thermal probe of Chandrayaan-3 penetrated up to 10 cm deep to record the first-ever in-situ high-latitude temperature profile. It revealed a massive vertical temperature gradient during the lunar morning and sub-zero temperatures below 8 cm. A sharp variation in thermal conductivity and diffusivity at a depth of ~6 cm revealed a distinct two-layer "cake-like" regolith structure.
- ChaSTE measurements also showed that the top 2 to 6 cm of lunar regolith is hyper-porous but highly cohesive, acting as an effective thermal blanket that insulates potential subsurface water-ice molecules.
- Measurements by the Alpha Particle X-ray Spectrometer (APXS) on the Pragyan rover within 50 meters of the landing site showed a highly uniform elemental composition. APXS detected elevated abundances of magnesium-rich minerals, supporting the Lunar Magma Ocean (LMO) hypothesis and suggesting deep mantle elements were ejected during the formation of the nearby South Pole-Aitken (SPA) basin. This confirms that the landing site contains primitive mantle material absent from existing equatorial Apollo/Luna collections.
- The RAMBHA-LP Langmuir probe onboard the Vikram lander conducted the first-ever high-latitude near-surface plasma measurements. It recorded electron densities ranging from 300 to 650 electrons/cm³ and elevated kinetic temperatures of 3000 to 8000 K, proving that the near-surface plasma is energetic, non-thermal, and heavily modulated by the solar wind and Earth's geomagnetic tail.
- The ILSA seismometer recorded over 250 distinct vibration events at the Shiv Shakti point. While ~200 events were successfully correlated to known mechanical operations of the rover and instruments, the remaining signals provide a pristine look into local lunar seismic activity.

All these results have been published in reputed scientific journals.

The success of Aditya-L1 and Chandrayaan-3 represents a turning point in India's space program, India becoming a major producer of primary, high-impact space science data.

- Beyond the initial national milestones, these missions are actively laying the empirical groundwork for India's long-term science roadmap, the upcoming Venus Orbiter Mission, Chandrayaan-4 and Chandrayaan-5/LuPEX (Lunar Polar Exploration), and next-generation planetary exploration.
- The deep-space navigation, halo orbit maintenance, and autonomous payload operations perfected via Aditya-L1 are directly feeding into the trajectory planning and thermal management architectures required for the Venus Orbiter Mission.
- The high-precision landing, sensor fusion, and autonomous hazard avoidance algorithms proven by Chandrayaan-3 form the baseline guidance systems for future sample return mission configurations, the immediate such mission being Chandrayaan-4.

These missions are also inspiring the studies of more complex missions from other Lagrange points in the Sun-Earth system, and in a broader sense, are integral parts of a long-term plan of space exploration.

This information was given by Union Minister of State for Prime Minister's office and Personnel, Public Grievances and Pensions, Atomic Energy and Space, Dr. Jitendra Singh, in a written reply in the Rajya Sabha today

NKR/AK/NM

