4. Aditya-L1 Mission - Space

Scientists from the Indian Institute of Astrophysics and NASA have made the first-ever spectroscopic observations of a coronal mass ejection (CME) in the visible wavelength range, close to the Sun's surface using the VELC payload on Aditya-L1

Aditya–L1 Mission - India's First Space-Based Solar Observatory

Introduction and Overview

Aditya-L1 is India's first space-based mission dedicated to studying the Sun, marking a major leap in India's solar and space science capabilities. It was launched on September 2, 2023, by the Indian Space Research Organisation (ISRO) using the PSLV-C57 rocket from the Satish Dhawan Space Centre, Sriharikota. The spacecraft is positioned at the Lagrange Point 1 (L1) of the Sun–Earth system, approximately 1.5 million km away from Earth, or about 1% of the distance between Earth and the Sun. From this vantage point, the satellite can observe the Sun continuously — without interruptions caused by eclipses or occultations.

Mission Objectives

The mission aims to enhance our scientific understanding of the Sun's dynamics and its influence on space weather near Earth. Key scientific goals include -

1. Studying the solar corona (outermost layer) and its heating mechanisms.
2. Investigating solar flares and coronal mass ejections (CMEs), which can disrupt Earth's communication systems and power grids.
3. Examining the magnetic field variations near the Sun.
4. Measuring solar wind (charged particles emitted by the Sun) and their interaction with Earth's magnetosphere.
5. Enhancing models that predict space weather, improving safety for satellites, astronauts, and electrical systems.

Orbit and Position – The Significance of Lagrange Point 1

About Lagrange Points - Lagrange points are positions in space where the gravitational forces of two large bodies (e.g., the Sun and the Earth) and the centrifugal force of a smaller body (e.g., a satellite) are in equilibrium. This balance enables the smaller object to remain stable relative to the two larger bodies. The Sun–Earth system has five Lagrange points (L1 to L5) -

1. L1 - Between Earth and Sun – best for continuous solar observations.
2. L2 - Beyond Earth, opposite the Sun – used for space telescopes like JWST.
3. L3, L4, L5 - Lie along or form equilateral triangles with the Sun–Earth line, used for gravitational studies.

Why L1 is Ideal for Solar Missions - From L1, a spacecraft can view the Sun without obstruction, enabling real-time observation of solar activity. It provides an early warning system for space weather disturbances heading toward Earth.

Halo Orbit – Maintaining Position Around L1

Aditya-L1 follows a halo orbit around the L1 point — a three-dimensional periodic loop around the equilibrium position. Unlike circular orbits around planets, a halo orbit keeps the spacecraft in continuous line of sight of both the Sun and Earth. Advantages of a halo orbit include -

1. No shadowing by the Earth or Moon.
2. Stable observational geometry for solar instruments.
3. Reduced fuel consumption for orbital maintenance.

Scientific Payloads on Board

Aditya-L1 carries seven scientific payloads, all indigenously developed by Indian institutions — five by ISRO centres and two with academic collaborations. These instruments study different layers of the

Sun and its emissions -

(A) Remote Sensing Instruments (observe the Sun's atmosphere directly) - Visible Emission Line Coronagraph (VELC) - Built by the Indian Institute of Astrophysics (IIA), Bengaluru. Studies the solar corona and coronal mass ejections (CMEs).

Solar Ultraviolet Imaging Telescope (SUIT) - Developed by IUCAA, Pune. Observes the photosphere and chromosphere in ultraviolet light. Solar Low Energy X-ray Spectrometer (SoLEXS) and High Energy L1 Orbiting X-ray Spectrometer (HEL1OS) - Measure solar flares and X-ray emissions, giving insights into high-energy solar processes.

(B) In-situ Instruments (study particles and fields in the solar wind near L1) - Aditya Solar Wind Particle Experiment (ASPEX) and Plasma Analyser Package for Aditya (PAPA) - Measure the solar wind and energetic particle fluxes.

Magnetometer - Measures interplanetary magnetic field variations near the L1 region.

Strategic and Scientific Significance

A. Contribution to Space Weather Forecasting - Aditya-L1 enables real-time monitoring of solar storms, helping predict geomagnetic disturbances that can disrupt -

1. Satellites and navigation systems,
2. Power transmission grids,
3. Radio communications, and
4. Airline operations on polar routes.

B. Complementing Global Solar Missions - Works in coordination with NASA's Parker Solar Probe (studying solar plasma closer to the Sun) and ESA's Solar Orbiter (mapping the Sun's poles). Together, these missions provide a multi-dimensional view of solar activity — from the solar surface to interplanetary space.

C. Boost to India's Space Science Ecosystem - Demonstrates India's capability to build and operate observatory-class space missions, comparable to major international programs. Encourages collaborative solar research between ISRO and Indian academic institutions like IIA, IUCAA, and PRL.

D. Strategic Importance - Enhances India's technological independence in space weather monitoring, reducing reliance on foreign datasets. Provides critical inputs for protecting communication and defense satellites. Supports Gaganyaan human spaceflight mission by improving understanding of solar radiation hazards. Strengthens India's role in global space research networks and in upcoming interplanetary exploration missions.

Challenges and Future Prospects

Challenges - Maintaining precise orbital stability around L1, 1.5 million km away, with minimal fuel. Handling intense solar radiation and heat exposure affecting sensitive instruments. Ensuring long-term data calibration for consistent observation accuracy.

Future Prospects - The mission will generate high-resolution solar data crucial for space weather modeling. Its success may pave the way for future deep-space observatories, such as missions to L2 orbits for astronomy and climate studies. It strengthens India's preparation for manned and deep-space missions through enhanced understanding of solar radiation effects.

Conclusion

Aditya-L1 is a landmark achievement showcasing India's progress from Earth observation to solar and interplanetary observation capabilities. It symbolizes India's scientific maturity, technological innovation, and global contribution to space science. By enabling continuous, indigenous solar monitoring, Aditya-L1 supports India's long-term goals of space weather readiness, astronomical advancement, and sustainable space exploration.

Source - https - //www.thehindu.com/sci-tech/science/aditya-l1-iia-nasa-collaborate-to-record-spectroscopic-observations-of-a-cme-in-visible-wavelength-range-for-very-first-time/article70258711.ece