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Hindustan Times

FIRST VOICE. LAST WORD.

{ SOLAR MISSION }

All systems ready for Aditya-L1 launch today

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NEW DELHI: The Indian Space Research Organisation (Isro) on Friday began the 23-hour, 40-minute countdown for the Aditya-L1 spacecraft's launch scheduled on Saturday, with the space agency's boss expressing confidence in the mission achieving its objectives.

The launch comes close on the heels of Isro landing successfully, for the first time for any country, on the surface of the moon near the south pole, where its Chandrayaan-3 rover is carrying out a variety of experiments to understand the Earth's only natural satellite.

On the Aditya-L1, Isro chairman S Somanath said: "The rocket is ready for launch. The mission will unveil a lot of secrets about the Sun, which is the nearest star to earth. Unlike Chandrayaan-3, which is a 14-day mission, Aditya (L1) has a longer mission life, because the distance that needs to be travelled by the spacecraft is more".

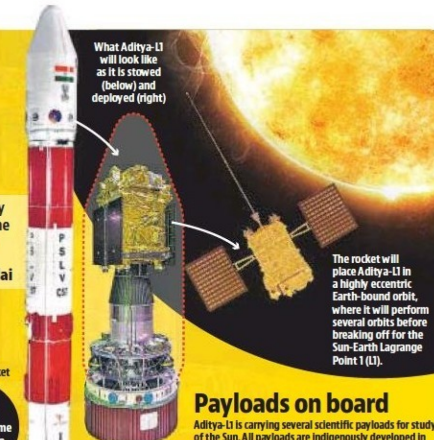
→P2

{ ISRO } NEW MISSION KICKS OFF

Countdown begins

Aditya-L1 to launch today

Launching today, Aditya-L1 is India's first observatory that will study the Sun from space. Just days after the roaring success of the Chandrayaan-3, a look at how this mission seeks to cement India's position at the forefront of global space race. By Soumya Pillai



Launch vehicle

Isro on Friday began the 23-hour, 40-minute countdown for the Aditya-L1 spacecraft's launch scheduled on Saturday, with the space agency's boss expressing confidence in the mission achieving its objectives. Aditya-L1 will launch from the Satish Dhawan Space Centre (SDSC) in Sriharikota on board the Polar Satellite Launch Vehicle (PSLV) XL today, just 10 days after Chandrayaan-3's landing

Time of launch
11:50 AM
PSLV-XL is the heavy cargo carrying version of Isro's workhorse PSLV rocket

44.4m vehicle height

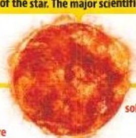
321 tonnes Lift-off mass

125 days the time it will take to reach L1

Science objectives

The primary overall objective of the mission is to observe the solar atmosphere – mainly, the chromosphere and the corona, the two outermost layers of the star. The major scientific objectives include

- Understanding the coronal heating and solar wind acceleration
- Understanding initiation of coronal mass ejection, flares and near-Earth space weather
- To understand coupling and dynamics of solar atmosphere
- To understand solar wind distribution and temperature anisotropy



Payloads on board

Aditya-L1 is carrying several scientific payloads for study of the Sun. All payloads are indigenously developed in collaboration with Isro centres.

ASPEX: Aditya Solar wind Particle Experiment contains particle spectrometers to measure solar wind particles

SUIT: Solar Ultraviolet Imaging Telescope will look at the Sun using narrow- and broad-band spectral filters in near-UV range

HEL1OS: High Energy L1 Orbiting X-ray Spectrometer will study the release of energy, acceleration and transport of electrons in solar flares

VELC: Visible Emission Line Coronagraph (VELC), the primary payload of Aditya-L1, will be sending 1,440 images per day to the ground station for analysis on reaching the intended orbit

SoLEXS: Solar Low Energy X-Ray Spectrometer is a soft X-ray spectrometer

MAG: MAGnetometer is a magnetic sensor to measure interplanetary magnetic field and study solar events such as coronal mass ejections

PAPA: Plasma Analyser Package for Aditya-L1 contains sensors that will study the composition of solar winds

The Sun, and how it has fuelled humanity's curiosity, knowledge

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NEW DELHI: In Jules Verne's classic *Around the World in Eighty Days*, the Sun can be said to be one of the central figures. Phileas Fogg and his fellow travellers see the Sun rise and set 80 times during their round trip from west to east, and therefore presume that 80 days and nights must have elapsed. It takes Fogg a little bit of arithmetic to correct one of literature's most famous miscalculations and collect his bet in the nick of time the following day. Travelling in that direction and seeing 80 sunrises and 80 sunsets, as he works out, could only have meant that 79 days had elapsed.

The Sun, the source of all energy that sustains life on Earth, has inspired knowledge for as long as humanity has existed. Isro's Aditya-L1 mission, launching on Saturday, seeks to add to our knowledge about the physics and chemistry at play around the Sun, concepts that are far more complex than the arithmetic in Verne's novel. Fogg's correction can be explained either with longitudes (as Verne did) or simply with the relative motion between two objects charting the same circular path in opposite directions.

PICK OF THE DAY

Even that, however, would be far more advanced than the knowledge of the ancients who believed the Earth was flat.

Growth of knowledge

Much of our early knowledge, particularly of geometry, trigonometry and astronomy, is a result of a curiosity to understand the motion and the influence of the heavenly bodies. While their mathematical observations were remarkable given the constraints of their times, many early scholars also dwelt on the supposed astrological influence of the heavenly bodies, which has no connection with what modern science has taught us.

The accumulation of knowledge would have started with the obvious observation that the Sun gives us days and nights. Deification was inevitable; countless civilisations have had countless sun gods, and indeed Sun-worshippers exist even today.

Eclipses captivated scholars early on, with the earliest known records (in Ugarit, now in Syria) dating back more than three millennia ago. Eventually, eclipses would inspire calculations that would establish the Earth as round, and also attempts to determine the Sun's distance from our planet. Early models of the Earth-Sun system, however, placed the Earth at the centre of the universe, with other heavenly bodies including the Sun revolving around the planet.

The modern model of the Solar System arose out of the work of Copernicus in the 16th century, and improved on by Kepler in the 17th. This model placed the Sun at the centre, with the planets including Earth (which spins on its axis) orbiting their star while the Moon orbits the Earth. A millennium before Copernicus and Kepler, incidentally, Aryabhata of India had correctly proposed that the Earth spins on its axis, although he had placed the Earth at the centre of the Universe.


The Sun, the source of all energy that sustains life on Earth, has inspired knowledge for as long as humanity has existed. AP

Celebrated scientists weighed in on Copernicus and Kepler's work. Galileo's telescopes enabled closer observations of the Sun, including sunspots; Descartes described the Sun as one of many stars (unlike Copernicus and Kepler who had thought it distinct); and Newton's mathematics provided a reasonably accurate estimate of the mass of the Sun.

Later advancements included solar spectroscopy, knowledge that the Sun rotates at differential rates and therefore must be made of fluid in the outer layers, and about the Sun's chemical composition, its magnetic nature and solar flares, which are bursts of radiation ejected from the ball of fire.

What more to learn

We know today that the Sun is made of plasma, which is a super-ionised gas that is moving constantly. Energy from the Sun, created as a result of nuclear fusion reactions, reaches us through light or bursts of magnetism or particles. These can influence the space environment, and missions probing the Sun seek to understand the ways in which that can happen.

NASA has several solar missions include the Parker Probe, while The European Space agency has a solar orbiter. NASA lists several reasons for studying the Sun: the influence of its radiation that can be either a boon or hazard for life on Earth; its influence on space weather, space technology and communications systems; and the fact that it is the only star we can study up close, learning more about other stars in the process.

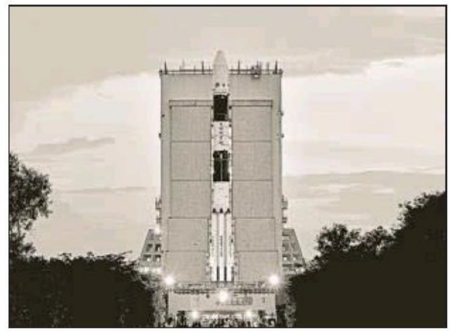
Isro's Aditya-L1 mission too will study radiation and its influence on space weather and space infrastructure. It will be in halo orbit around a point called L1, 1.5 million kilometres from Earth, chosen because it offers observations without hindrance from phenomena such as eclipses.

"Various spacecraft and communication systems are prone to such disturbances and therefore an early warning of such events is important for taking corrective measures beforehand. In addition to these, if an astronaut is directly exposed to such explosive phenomena, he/she would be in danger," a booklet on the mission says.

"Thus, the Sun also provides a good natural laboratory to understand those phenomena which cannot be directly studied in the lab."

Aditya will shape the next phase of our space forays

The mission to the Sun will enrich our understanding of the solar corona and space weather, and make forecasts better. The data collected by its state-of-the-art instruments will be a shot in the arm for Indian researchers



The Indian Space Research Organisation's next ambitious mission is the Aditya-L1, which is India's first dedicated mission to study the Sun PTI

Annapurni Subramaniam

In the last 10 days, the landscape of global space exploration has undergone a dramatic transformation. India pole-vaulted to the front row of space exploration, with the successful soft-landing on the southern polar region of the Moon. The precision and the frugal economics with which the mission was executed attracted the attention of not only the nation but also the world. Before we could take a breath and absorb this stupendous feat, the Indian Space Research Organisation (Isro) announced the launch of its next ambitious mission — the Aditya-L1. This is the first dedicated mission to study the Sun. For the first time, the Indian space mission is flying to the Sun-Earth L1 lagrange point (the point of equilibrium where a small-body object can stay put under the opposing gravitational pulls of two large-body objects), which is about 1.5 million km away.

In scientific missions, the first requirement is the definition of the outstanding science question at hand, followed by detailing the experiment that needs to be performed to answer the question, and finally, design, fabrication and space qualification of the instrument. Let us look at the why, what and how of this mission.

The Sun is the star we live with, and there are several compelling questions that are unanswered about it, such as the mechanics of the heating of the solar corona (the outermost part of the Sun's atmosphere), solar activity and space weather. The Sun is very dynamic on very small time-scales such as minutes to very long time-scales such as the 11-year-long cycle of its magnetic activity, which flips every decade. The mass ejections from the corona cause a lot of disturbance in space, resulting in damage to our space assets. These demand an unobstructed view of the Sun from a vantage point and 24/7 monitoring. The instruments on the Aditya-L1 mission, therefore, are designed to answer such scientific questions, including understanding space weather. When placed in an orbit around the Sun-Earth L1 lagrange point, the instruments will have an uninterrupted view of the Sun.

The Aditya-L1 mission is the upgraded version of a small foray with a coronagraph (which blocks out light emitted by the Sun's actual surface, so that the corona can be observed), originally proposed about one-and-a-half decades ago. It was around the early 2010s when the mission objectives were enhanced, including the modification of the orbit to the Sun-Earth L1 lagrange point.

Along with this, more scientific instruments from various Indian institutions were also included. The main objective was to continuously monitor the Sun and its activities, make measurements of the energetic phenomena that control the space weather, and sample the space environment near the L1 point that moves around the Sun along with the Earth.

With ever increasing dependency on space technology, our assets in space are soaring. The electronics on board need to perform without failure to carry out mission operations as well as communication. The space environment is harsh with criss-crossing charged particles, a good fraction of which originates from the Sun. The protection of our space asset depends crucially on our ability to understand the space weather and possibly predict the changes well in advance. The instruments on-board the Aditya-L1 mission will enhance our understanding of these phenomena and make such forecasts possible.

Space missions that travel beyond the Earth's sphere of influence are marked by two major challenges. One is space navigation and the other is communication with ground facilities. This is the first time Isro is launching a mission this far into space. Navigation in this direction is also being performed for the first time. With our capability to navigate to the Moon and Mars, this is not an insurmountable task. Not only reaching the Sun-Earth L1 point but also making a halo orbit, as the Earth moves around the Sun, are crucial tasks for the mission team.

There will be a variety of operations that need to be performed as part of this mission, which is definitely technologically daunting. Due to limited visibility of the spacecraft with Indian ground stations, Isro plans to collaborate with other agencies for communication and data download. The instruments that need to collect data 24/7 are certain to accumulate a large volume of it. The demand is not only to quickly download the data, but also to analyse it almost immediately to monitor the Sun's activity in near real-time. These requirements place a lot of demand on the communication links between the spacecraft and ground stations.

The seven instruments on-board this mission are of two types: Remote-sensing instruments that view the Sun and make measurements, and *in situ* instruments that make estimations at the location of the spacecraft. These instruments are highly sophisticated and perform very complex and precise measurements. High cadence and precise estimations of the dynamic Sun and its corona are expected to be a game changer in our understanding of the Sun.

Studies of the Sun in India have a very long history spanning more than 200 years. The Madras observatory, which was established in 1792, carried out studies of the Sun and other celestial objects. The experiments carried out during the 1868 total solar eclipse in Guntur contributed to the discovery of the element helium. The Kodaikanal observatory, currently a field station of the Indian Institute of Astrophysics (IIA), was set up in 1899 to carry out studies of the Sun using various ground-based instruments. More than 100 years of images of the Sun preserved by IIA are now digitised and made available to the scientific community to research on the long-term variations of the Sun.

The Indian solar physics community has played a very significant role in shaping the international landscape in solar research. In this context, the data collected by the state-of-the-art instruments on-board the Aditya-L1 mission will be a shot in the arm for Indian researchers. It will set new limits for our space ambitions

Annapurni Subramaniam is director, Indian Institute of Astrophysics.

The views expressed are personal