Aditya L-1

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Why is in news? Why ISRO's Aditya spacecraft is at 'L1', what it means

Aditya-L1 was launched by ISRO on September 2, 2023, with the mission of observing and helping us better understand the Sun.

It arrives at its destination, **L1 or the first Sun-Earth Lagrangian point**, on January 6.

Need for the study of the sun:

The Sun produces energy through **nuclear fusion** in its interior, and emits it from its outer layers.

The photosphere, a 6,000-degree Celsius layer, emits all visible and infrared light, crucial for lifeAbove is the chromosphere, and higher still is the million-degree Celsius hot corona.

Interestingly, the **corona is much hotter than the inner layers of the Sun —** there must be some energy source which provides this heat. However, the processes involved in this are **not yet fully understood**.

Moreover, it **also emits ultraviolet and X-ray radiation** which would be lethal to life on Earth, without the presence of the atmosphere which absorbs most harmful radiation.

The Sun also **continuously streams electrically charged particles —** a stream known as the Solar wind.

These charged particles produce the spectacular aurorae, known as the **Northern and Southern Lights**, seen close to the north and south poles of the Earth.

There are also sudden bursts and ejections of charged particles from the Sun into interplanetary space, known as **Solar flares and coronal mass ejections**.

These directly **affect space weather, space-reliant technologies** like satellite communication networks, and can **produce electric power blackouts** in Earth's higher latitudes. Notably, they can be **extremely difficult to predict**.

About the mission:

Aditya-L1 is the **first space based observatory class Indian solar mission** to **study the Sun** from a substantial distance of 1.5 million kilometers. It will take **approximately 125 days to reach the L1 point**.

Aditya-L1 is also **ISRO's second astronomy observatory-class mission** after AstroSat (2015).

The mission's journey is **notably shorter than India's previous Mars orbiter mission**, Mangalyaan.

The spacecraft is **planned to be placed in a halo orbit around the Lagrangian point** Since Aditya-L1 is located outside the Earth's atmosphere.

Moreover, we need to **monitor the solar atmosphere and the corona continuously** to monitor eruptions on the Sun, and study the properties of charged particles in the Solar wind.

This will then help **provide early warning of Solar eruptions**, and allow us to initiate actions to minimise the disruption they may cause.

Aditya-L1 has **seven instruments** for the observation of all the radiation and charged particles.

Halo-Orbit Insertion (HOI) of its solar observatory spacecraft, Aditya-L1 was accomplished at 16.00 Hrs (approx) on January 6, 2024 (IST). The final phase of the maneouver involved firing of control engines for a short duration.

The orbit of Aditya-L1 spacecraft is a **periodic Halo orbit** which is located roughly 1.5 million km from earth on the continuously moving Sun – Earth line with an orbital period of about 177.86 earth days.

This Halo orbit is a **periodic, three-dimensional orbit at L1** involving Sun, Earth and a spacecraft.

This specific halo orbit is selected to **ensure a mission lifetime of 5 years**, **minimising station-keeping manoeuvres** and thus **fuel consumption and ensuring a continuous, unobstructed view** of sun.

L1 - the location of Aditya:

L1 stands for the first Lagrangian point — there are five such points, L1 to L5, associated with the motion of one astronomical body around another one, in Aditya's case, Earth and the Sun.

These points were **theoretically discovered by the Swiss mathematician Leonhard Euler** and the **Italian-French mathematician Joseph-Louis Lagrange** in the 19th century.

We are particularly concerned here with points **L1 and L2** because of their relevance to space missions.

When a spacecraft is in orbit around Earth, it is affected by the gravitational force exerted on it by the planet.

Yet it does not fall to Earth's surface because effectively, **Earth's gravity is balanced by a centrifugal force** which arises due to the motion of the spacecraft around the Earth.

The Earth's gravitational pull on a spacecraft gets ever so weaker the further it moves from the planet. Eventually, there comes a point where Earth's gravitational force becomes comparable that exerted by the Sun.

If a spacecraft moves any further, it will get pulled into orbit around the sun, or eventually crash into it, depending on its speed.

L1 is the sweet spot between Earth and the Sun, where the gravitational force exerted on a spacecraft by the two celestial bodies, and the centrifugal force cancel each other.

As a result, once placed exactly at L1, Aditya would always continue to remain there without expending any energy.

Does this mean that Aditya is at a stationary point in space?

L1 is on the line joining the Sun and the Earth. As Earth rotates around the Sun, L1 goes around the Sun too, while always remaining on the same line.

Thus, rather than being at the same point in space, **Aditya will remain at the same position, relative to the Sun and Earth**.

In fact, the L1 point itself is fundamentally unstable — a tiny pull or push can send the spacecraft hurtling away in some other direction. To avoid this, Aditya is placed in an orbit around L1.

A complex orbit nearly perpendicular to the line joining the Sun and Earth, it will take the spacecraft about 178 days to complete one full orbit.

Why L1?

Putting Aditya in orbit around the Earth would have made the mission much simpler. However, this would also mean that Earth would cover Aditya's view of the Sun for significant periods of time.

While the duration of **such eclipses can be reduced by choosing the correct orbit**, it **cannot be fully eliminated**.

Given that Aditya is meant to act as an early warning system for solar flares and coronal mass ejections, is necessary to have an uninterrupted view of the Sun.

When Aditya is at L1, the Earth is always on one side of it, and the Sun on the other side. Thus, the spacecraft's instruments can be pointed towards the Sun for a completely uninterrupted view.

Even though placing the spacecraft at an orbit around L1 is complex, the benefits of having an uninterrupted view of the Sun at all times is well worth the effort, risk, and expense.

A few space missions are already parked around the L1 point, including the **LISA Pathfinder**, and **Solar and Heliospheric Observatory (SOHO),** both collaborative missions of NASA and European Space Agency.

What about L2?

While the L1 is the ideal point to observe the Sun, **L2 is a very useful staging point** for spacecraft to be used for **observing the distant Universe**

L2 also is along the line joining the Sun and Earth, but it is on the opposite side of the Earth, at about 1.5 million kilometres.

So, a spacecraft in a halo orbit around L2 can have all its instruments pointing away from the Earth, to get an uninterrupted view of the deep space.

The **James Webb Space Telescope (JWST), Gaia and Euclid** are some of the important astronomical probes which are presently in orbit around L2

The **Planck mission**, which carried out path breaking observations of the cosmic microwave background radiation was also located there.

Solar Space Program of Other Countries:

H?lios 2 Solar Prob?: In 1976, th? earlier Helios 2 solar prob? was a collaborative project b?tw??n NASA and the spac? ag?ncy of form?r W?st G?rmany. It approach?d within 43 million km of the Sun's surfac?.

Advanc?d Composition Explor?r (ACE) (NASA-1997): ACE is d?sign?d to analyz? solar wind and cosmic rays, offering insights into th? Sun's behaviour and its impact on th? int?rplan?tary ?nvironm?nt.

NASA's Parker Solar Probe (2018): Its key objective is to track the movement of energy and heat through the Sun's corona and also to investigate the source of acceleration of the solar winds. It is a component of **NASA's 'Living with a Star' initiative**, which explores various aspects of the Sun-Earth system.

Solar Orbit?r (2020): A Joint project b?tw??n ESA and NASA, Solar Orbit?r gath?rs data to address k?y qu?stions in h?liophysics.

Oth?r activ? Sun-Monitoring spac?craft:

Interface Region Imaging Spectrograph (IRIS) (NASA-2013),

WIND (NASA-1994),

Hinode (JAEA-2006),

Solar Terrestrial Relations Observatory (STEREO) (NASA-2006).

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