Source : www.thehindu.com Date : 2023-09-05

ADITYA-L1: ITS FUNCTIONING AND PURPOSE

Relevant for: Science & Technology | Topic: Achievements of Indians in science & technology

September 04, 2023 10:25 pm | Updated 10:34 pm IST

The ISRO launches solar mission, Aditya-L1 from Satish Dhawan Space Centre in Sriharikota on September 2. | Photo Credit: ANI

Usually when we huddle near a fire, we feel warm and as we move away, that warmth is reduced. But surprisingly the sun and its atmosphere don't follow this rule. Made up of a soup of positively charged protons, negatively charged electrons and other ions mixed with the solar magnetic field, extending somewhere between 10 and 20 solar radii from the surface of the Sun, the solar corona, the atmosphere of the Sun is an enigma. While the surface of the Sun is 5,600 degrees, the corona, interestingly, is about two million degrees. “We have some idea of why it is so, but the problem is not fully resolved,” says Dipankar Banerjee, Director of Aryabhatta Research Institute of Observational Sciences (ARIES). “Observations from Adtiya L1 will help us understand the dynamics of the Sun and how solar variability impacts the climate on Earth and affects the space weather,” he adds.

Discovered by mathematician Joseph Louis Lagrange, L1 is one of the five points located approximately 1.5 million kilometres away, where the gravitational forces of the Sun and the Earth are in equilibrium. Hence, a spacecraft placed at L1 orbits the Sun at the same rate as Earth and affords an uninterrupted view of the Sun, making it an ideal observation post for space-based solar observatories.

The L1 is currently home to the European Space Agency (ESA)- National Aeronautics and Space Administration (NASA) Solar and Heliospheric Observatory (SOHO) observing the Sun and its dynamics. Aditya L1 will join this observatory to unravel the mysteries of the dynamics of the Sun.

Launched on September 2, the craft will undergo five orbit-raising manoeuvres before being slingshot to the L1 point. The ship will coast for about four months before it reaches L1. At that stage, the thrusters will be fired to make the craft circle around the L1, placing it in what is known as a halo orbit around L1. From this vantage point, Aditya L1 can observe the Sun 24X7 using its four remote sensing payloads, and measure in-situ the various parameters of space weather.

Like a heartbeat, solar activity is measured in terms of the number of sunspots. Sunspots are cooler regions on the Sun's surface which increase and decrease in a cycle of 11 years. When the Sun is active, the number of sunspots is in the hundreds, and at solar minimum, the numbers are nearly zero. However, according to Anamparambu Ramaprakash, who is with the

Pune-based Inter-University Centre for Astronomy and Astrophysics, “despite the variation in solar activity, the emission in visible and long wavelengths is nearly steady. Whatever changes we observe in the solar radiation, nearly 80% occur in the ultraviolet range,” he says. The Earth’s upper atmosphere absorbs most of the solar UV rays. “The absorbed energy affects the atmosphere’s composition, temperature and other parameters. It is imperative to know how far variation in the UV rays emitted by the Sun contributes to climate variability on Earth,” he adds.

The Solar Ultraviolet Imaging Telescope (SUIT) developed by the Inter-University Centre for Astronomy & Astrophysics, in close collaboration with the ISRO, the Center of Excellence in Space Sciences India, Mohanpur, the Manipal Academy of Higher Education etc, will observe the UV radiation from different zones of the solar atmosphere. The onboard intelligence system will detect any sudden appearance of bright spots, such as solar flares (a sudden burst of high energy visible light, UV rays, X rays and Gamma rays) on the disc. The automated system will trigger the rapid imaging of different layers, and thus, we will obtain a 3D tomographic view of the Sun. “With this system in place, the event’s progression through the layers of the solar atmosphere can be imaged,” says Mr. Ramaprakash. Combining the data from the Solar Low Energy X-ray Spectrometer (SoLEXS) and the High Energy L1 Orbiting X-ray Spectrometer (HEL1OS) developed by the ISRO’s Bengaluru based U. R. Rao Satellite Centre with SUIT, “ can [help us] gain insights into the emergence, progression and energetics of transient events on the surface of the Sun in the UV region”.

Observing the Sun using the SUIT will enable us to better understand climate variation on Earth. “Earth’s climate has definitely changed. Global warming is real. The data from SUIT and other papers of Aditya L1 will help us resolve the contribution of natural and anthropogenic factors driving climate change,” says Mr. Ramprakash.

At times, the Sun sneezes. Like a tongue of fire, a chunk of the corona suddenly accelerates and leaps into interplanetary space. Called Coronal Mass ejection (CME), this cloud consisting of billion tonnes of energetic plasma mixed with a solar magnetic field is hurled at 250 kilometres per second to 3,000 km/s.

Usually, the corona is not visible in the glare of the radiant Sun, except during the brief moment of a total solar eclipse. However, solar physicists can create artificial eclipses in the solar telescope, called coronograph, to observe the corona. Hitherto, no space telescope could peer at the inner corona, closer to the Sun. “They could look at either 1.1 solar radii or larger,” says Ravindra Belur, Professor of Solar Physic at the Bengaluru-based Indian Institute of Astrophysics. “However, theoretical study indicates that the acceleration of the coronal mass ejection happens below 1.1 solar radii,” he adds. With no insight into the solar corona’s inner part dynamics, we are yet to fully understand the mechanism that drives the CMEs.

The Visible Emission Line Coronagraph (VELC) developed by the Bengaluru-based Indian Institute of Astrophysics in close collaboration with the ISRO can peek as close as 1.05 solar radii, a region never imaged by any solar telescope. From 1.05, it can scan upto three solar radii. With this unique capability of VELC, “we can get crucial information about the mechanism responsible for CME acceleration,” says Mr. Ravindra.

Along with sunlight and electromagnetic radiation, such as ultraviolet rays, the Sun emits a constant stream of charged particles and a mixture of solar magnetic fields that travel throughout interplanetary space. Called a solar wind, the average speed of the flow near the Earth is about 300 kilometres per second. The solar wind constantly rams the Earth’s magnetosphere, which functions like a shield and deflects most of it. Nevertheless, the energetic particles from the solar wind sneak through the weak magnetic regions of the Earth — the north and south poles and interact with the molecules in the atmosphere, creating the dazzling display of aurora.

Violent eruptions like solar flares and CMEs trigger a strong wind or solar storm. A geomagnetic storm occurs when the solar storm bashes the Earth's magnetosphere. While brilliant, beautiful auroras appear as more energetic particles flow through the north and south poles, GPS and short-wave communication are disrupted, and the electronics in the satellite are in danger. Intense geomagnetic storms can induce magnetic-induced currents in the power grid and pipelines, resulting in power outages and fire. The energy from the charged particles heats the upper atmosphere, increasing the density and causing extra drag on satellites in low-earth orbit.

The changes in the solar wind's density, speed and direction is called space weather. Solar storms result in inclement space weather. Aditya L1 will function as a space weather station. The Aditya Solar Wind Particle Experiment (ASPEX) developed by the ISRO's Ahmedabad-based Physical Research Laboratory, the Plasma Analyser Package For Aditya (PAPA) developed by the Thiruvananthapuram based Vikram Sarabhai Space Centre and the advanced Tri-axial High-Resolution Digital Magnetometers developed by the Bengaluru based ISRO's Laboratory for Electro-Optics Systems keep a constant watch over the parameters of space weather near Aditya L1. Using the data from these instruments, scientists can predict probable geomagnetic storms and better understand space weather dynamics.

"Near Earth environ is filled with hundreds of satellites and the change in the space weather can affect them directly. The trajectory can be deflected by impact of a solar storm on upper atmosphere. ISRO alone has 50,000 crore worth of space assets," says Mr. Dipankar. Understanding space weather is an international issue, and the data from Adtiya L1 will aid in making models and predicting storms in advance.

T.V. Venkateswaran is Scientist at Vigyan Prasar, Dept of Science and Technology

Text and Context / The Hindu Explains / ISRO / space programme

BACK TO TOP

END