ADITYA L1 MISSION: SCIENCE & TECHNOLOGY

NEWS: *Aditya-L1 Mission Captures First-Ever Image of Solar Flare 'Kernel'*

WHAT'S IN THE NEWS?

The Indian Space Research Organisation (ISRO) announced that its Aditya-L1 mission has successfully captured the first-ever image of a solar flare 'kernel' using the Solar Ultraviolet Imaging Telescope (SUIT) payload.This marks a significant advancement in understanding solar flare dynamics and energy transfer in the Sun's atmosphere.

Key Observations from Aditya-L1's SUIT Payload

- The **SUIT payload** aboard **Aditya-L1** captured the image in the **lower solar atmosphere**, specifically in the **photosphere and chromosphere**.
- The solar flare was observed in the **Near Ultraviolet (NUV) wavelength range** of **200-400 nm**, an unprecedented achievement in solar research.
- The **flare detected was an X6.3-class solar flare**, one of the **most intense solar eruptions** recorded.
- The observation confirmed that **energy released from the flare spreads through different layers of the Sun's atmosphere**, validating existing solar flare models.
- The **localized brightening in the lower solar atmosphere** was found to **correspond with an increase in plasma temperature** in the **solar corona**.
- These findings reinforce theories linking **flare energy deposition to temperature evolution in the Sun's outer layers**.

Overview of Aditya-L1 Mission

- **Aditya-L1 is India's first space-based observatory** dedicated to studying the **Sun and solar activity** from space.
- It is designed to monitor **solar emissions, flares, and space weather phenomena** that impact Earth's climate and satellite communications.

Key Payloads of Aditya-L1

Aditya-L1 is equipped with **seven advanced payloads** to study various solar phenomena:

1. **Visible Emission Line Coronagraph (VELC)** – Observes the corona and studies coronal mass ejections (CMEs).
2. **Solar Ultraviolet Imaging Telescope (SUIT)** – Captures high-resolution images of the **photosphere and chromosphere** in the **Near Ultraviolet (NUV) spectrum**.
3. **Solar Low Energy X-ray Spectrometer (SoLEXS)** – Monitors soft X-ray emissions from solar flares.
4. **Aditya Solar wind Particle Experiment (ASPEX)** – Studies solar wind properties and its interactions with Earth's magnetosphere.
5. **High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)** – Detects high-energy X-rays from solar flares.

6. **Plasma Analyser Package for Aditya (PAPA)** – Analyzes the solar wind's composition and energy distribution.
7. **Advanced Tri-axial High-Resolution Digital Magnetometers** – Measures magnetic field variations in space.

Understanding Lagrange Points and Aditya-L1's Orbit

- The "L1" in **Aditya-L1** refers to the **Lagrange Point 1**, a special position in space where the **gravitational forces of the Sun and Earth** balance the **centrifugal force of a satellite**.
- Lagrange points are important for space missions as they **reduce fuel consumption** required to maintain a stable orbit.

Types of Lagrange Points in the Sun-Earth System

1. **L1 (Lagrange Point 1)**:
    - Positioned between the **Sun and Earth**.
    - Provides an **uninterrupted view of the Sun**, making it ideal for solar observation missions like **Aditya-L1** and **SOHO (Solar and Heliospheric Observatory).**
2. **L2 (Lagrange Point 2)**:
    - Located on the **opposite side of the Earth from the Sun**.
    - Used by deep-space observatories such as **James Webb Space Telescope (JWST)**.
3. **L3 (Lagrange Point 3)**:
    - Lies directly behind the Sun, **opposite to Earth's orbit**.
    - Not widely used due to communication difficulties.
4. **L4 and L5 (Stable Lagrange Points)**:
    - Form **equilateral triangles** with the Sun and Earth.
    - Natural accumulation points for small celestial bodies (e.g., asteroids known as **Trojans**).

Solar Flares and Their Impact

What is a Solar Flare?

- A **solar flare** is a **sudden, intense burst of energy** originating from the **Sun's atmosphere**, caused by the **reconnection of magnetic fields**.
- It releases energy in the form of **light, radiation, and high-energy particles**, which can **disrupt satellite communications, power grids, and navigation systems on Earth**.

What is a Solar Flare 'Kernel'?

- In solar physics, the **'kernel' of a solar flare** refers to:
    - The **brightest and most concentrated region** observed in the **lower layers of the Sun's atmosphere** during a flare.

- It is a site of **rapid heating and plasma upflow** during the **rise phase of a solar flare**.
- Studying kernels helps scientists understand the **energy transfer process from the Sun's core to its outer layers**.

Classification of Solar Flares

Solar flares are categorized based on their **peak X-ray flux** in the **1 to 8 Angstrom range**, as measured by the **Geostationary Operational Environmental Satellites (GOES)**.

Types of Solar Flares

1. **A-Class Flares** (Weakest):
   - Peak flux: **10^{-8} W/m²**.
   - Minimal impact, barely distinguishable from background solar radiation.
2. **B-Class Flares**:
   - Peak flux: **10^{-7} W/m²**.
   - **Ten times stronger than A-class** but still has negligible impact on Earth.
3. **C-Class Flares**:
   - Peak flux: **10^{-6} W/m²**.
   - Considered **minor flares** with **little effect on Earth**.
4. **M-Class Flares** (Moderate intensity):
   - Peak flux: **10^{-5} W/m²**.

- Can cause **temporary radio blackouts in Earth's polar regions**.
- Sometimes associated with **small radiation storms**.

5. **X-Class Flares** (Most powerful):
    - Peak flux: **10^{-4} W/m² or higher**.
    - Can trigger **planet-wide radio blackouts and long-lasting radiation storms**.
    - Each numerical increment represents a **tenfold increase in energy output** (e.g., **X2 flare is twice as powerful as an X1 flare**).

Significance of X6.3-Class Flare Observed by Aditya-L1

- The captured **X6.3-class solar flare** is one of the **strongest flares recorded**.
- Such flares have the potential to cause:
    - **Severe space weather disruptions** affecting satellite operations.
    - **Increased radiation hazards for astronauts** and aircraft flying over polar regions.
    - **Geomagnetic storms** that may impact Earth's **power grids and communication networks**.

Significance of Aditya-L1's Discoveries

- **First-ever direct imaging of a solar flare kernel** in the **NUV spectrum**.
- Enhances understanding of **solar energy transfer mechanisms** from the Sun's **core to its outer atmosphere**.
- Helps improve **space weather forecasting**, reducing risks to **satellites, astronauts, and Earth's communication systems**.
- Strengthens India's position in **solar research and space exploration**, contributing to global scientific advancements.

Source: https://www.thehindu.com/sci-tech/science/aditya-l1-payload-captures-the-first-ever-image-of-a-solar-flare-kernel/article69274469.ece