

# Magnetic Activity Driving Microwave Polar Brightening in the Sun

*Prelims: Current events of national and international importance | Science & Technology*

## Why in News?

Recently, research was conducted by scientists at the Indian Institute of Astrophysics (IIA) investigating the mechanisms behind solar microwave polar brightening.

- **Led by** - Aryabhata Research Institute of Observational Sciences (ARIES), Nainital in collaboration with the Udaipur Solar Observatory (USO) / Physical Research Laboratory (PRL) and IIT Roorkee.
- The team uncovered the magnetic mechanism driving "**Microwave Polar Brightening**" (also called **microwave aurorae**) in the Sun.

## Key Scientific Findings

- **The Phenomenon of Polar Brightening:**
  - When observed at high radio frequencies (particularly in the **microwave spectrum, around 17-37 GHz**), the solar poles appear noticeably brighter than the quiet central disk of the Sun.
  - This microwave enhancement originates in the upper **chromosphere and low transition region** of the solar atmosphere.
- **Dual Magnetic Drivers (Large-Scale vs. Small-Scale):**
  - **Large-Scale Poloidal Fields** - Microwave polar brightening reaches its maximum intensity during **solar activity minima** (when global activity like sunspots is low) because the global polar magnetic fields are strongest at this stage of the 11-year solar cycle.
  - **Small-Scale Unipolar Magnetic Elements** - High-resolution magnetic maps showed that the brightening is not uniform.
  - It is concentrated in concentrated patches driven by small, intense, unipolar magnetic structures (unipolar network elements) embedded near the poles.
- **Thermal Structure & Plasma Physics**
  - The presence of these small-scale magnetic elements causes localized heating in the solar plasma.
  - This elevated electron temperature and density increase **free-free thermal bremsstrahlung radiation** at microwave frequencies.

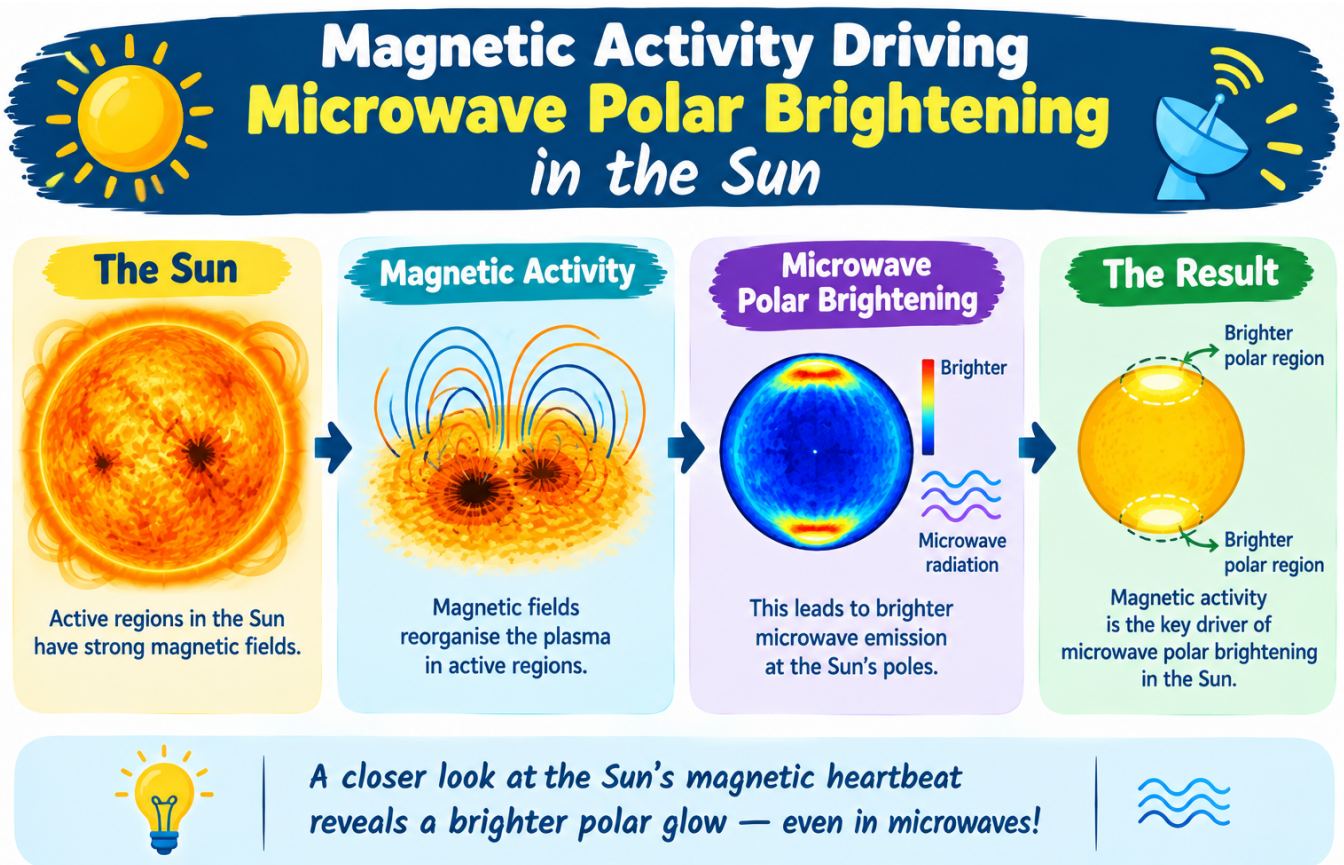
## Solar Dynamics Across the 11-Year Solar Cycle

| Solar Cycle Phase | Global Magnetic State | Polar Microwave Brightening Behavior |
|-------------------|-----------------------|--------------------------------------|
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|                      |                                                                                                  |                                                                                                                                       |
|----------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Solar Minimum</b> | Strong, well-defined global polar magnetic fields; low active-region sunspot count.              | <b>Maximum Brightening</b> - Enhanced concentration of unipolar magnetic network elements at the poles.                               |
| <b>Solar Maximum</b> | Global polar fields weaken, decay, and undergo field reversal; high active-region sunspot count. | <b>Minimum Brightening</b> - Disruption and dispersal of polar magnetic structures cause a sharp decline in polar microwave emission. |

## Significance

- It provides a reliable proxy for measuring the strength of the Sun's poloidal magnetic field, which is critical for predicting the strength and timing of future solar cycles.
- Offers fresh insights into coronal heating mechanisms, regarding why the outer solar atmosphere (corona) is millions of degrees hotter than the underlying solar surface (photosphere).
- Complements measurements from space missions like
  - **Aditya-L1** (India's flagship solar observatory) and
  - NASA/ESA's **Solar Orbiter**, enhancing forecasting models for solar wind acceleration, coronal mass ejections (CMEs), and geomagnetic disturbance risks to satellite operations.



## Reference

[PIB | Large- and small-scale magnetic activity](#)



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