



Large- and small-scale magnetic activity driving microwave polar brightening in the Sun

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Researchers have probed the mystery of why the poles of the Sun shine much brighter than the rest of the solar disk when mapped at certain specific microwave and radio frequencies.

The study could provide valuable insights into the magnetic field and temperature conditions in the Sun's polar atmosphere.

The Sun's polar regions play an important role in the evolution of its magnetic field and the generation of the solar wind. However, despite decades of observations, the cause of microwave polar brightening, the enhanced radio emission seen near the Sun's poles, has remained unclear.

Microwave polar brightening appears as an increase in radio brightness near the Sun's poles. Earlier studies have linked this brightening to features such as polar coronal holes, polar faculae, and magnetic fields. Coronal holes are dark regions in EUV images where magnetic field lines are predominantly open, allowing the fast solar wind to escape. However, the contribution of each of these features and their role in the long-term behaviour of microwave polar brightening have not been fully understood.

In a recent study carried out through a collaboration of researchers from the Aryabhata Research Institute of Observational Sciences (ARIES), Nainital, an autonomous research institute under the Department of Science and Technology (DST), Government of India, Udaipur Solar Observatory (USO)/ Physical Research Laboratory (PRL), IIT Delhi and IIT Roorkee, a comprehensive investigation of microwave polar brightening was carried out using nearly three decades of observations from the Nobeyama Radioheliograph (NoRH) operating at 17 GHz.

The radio data were combined with extreme-ultraviolet observations from NASA's Solar Dynamics Observatory and magnetic field measurements from the Wilcox Solar Observatory to investigate the origin and long-term evolution of this phenomenon.

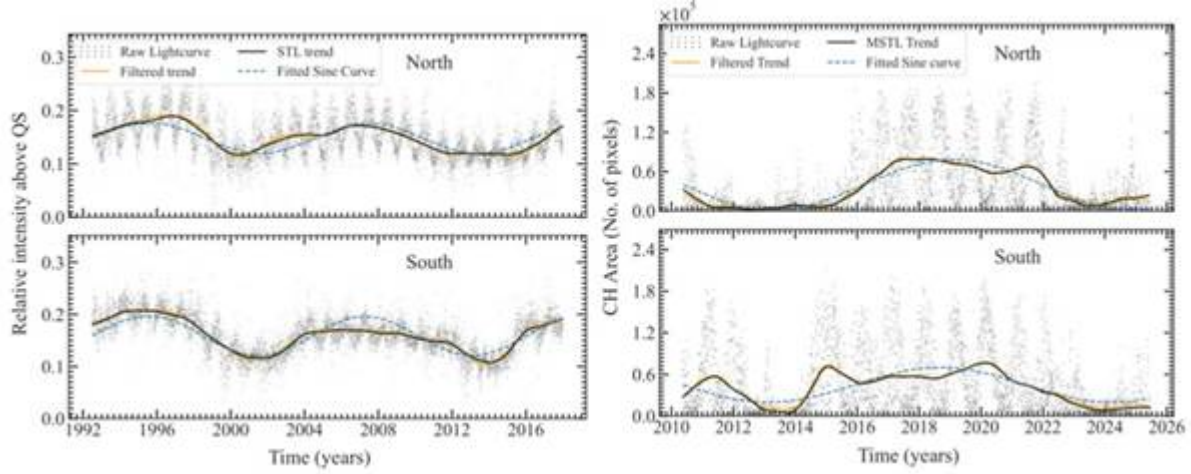


Fig 1: Long-term evolution of microwave polar brightening and polar coronal hole area at the north and south poles derived from Nobeyama Radioheliograph observations. The observations reveal clear solar-cycle variation and hemispheric asymmetry.

The research team, led by Mr. Rohan Bose, a DST INSPIRE Senior Research Fellow affiliated with ARIES, Nainital, and IIT Roorkee, along with Dr. Anshu Kumari (USO/PRL), Dr. Vaibhav Pant (IIT Delhi), and other collaborators, revealed a clear north-south difference in the long-term evolution of microwave polar brightening and the area of polar coronal holes.

To understand the role of coronal holes, the researchers compared microwave observations with the areas of polar coronal holes identified from extreme-ultraviolet (EUV) images. The study found a strong relationship between microwave polar brightening and the size of polar coronal holes. An even stronger relationship was observed between microwave polar brightening and the strength of the Sun's polar magnetic field. These findings show that the long-term changes in microwave polar brightening are closely connected to the magnetic structure of the Sun's polar atmosphere.

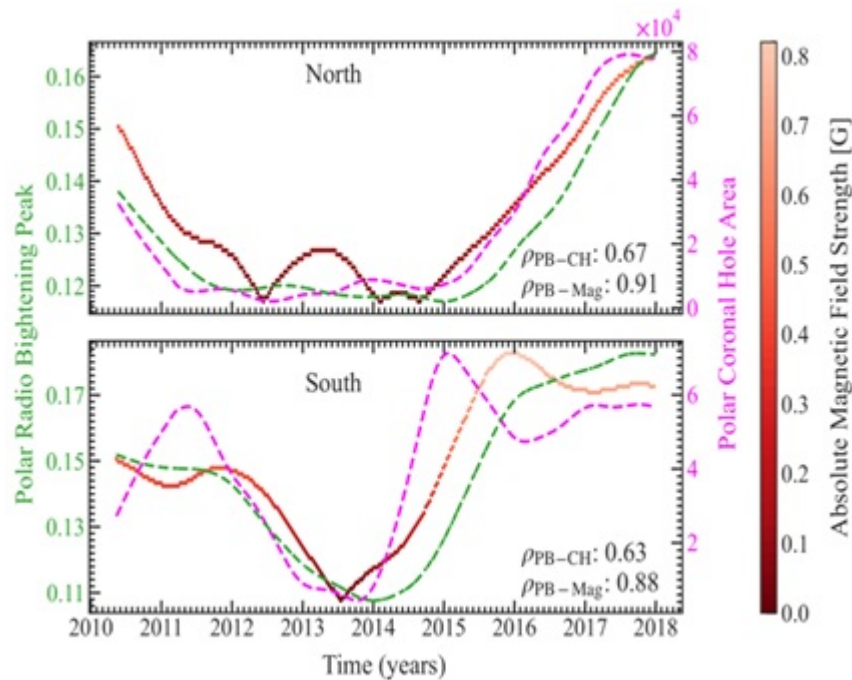


Fig 2: Comparison of microwave polar brightening with polar coronal-hole area and polar magnetic-field strength. Strong correlations are observed between all three quantities.

The researchers also examined individual microwave bright patches by comparing microwave observations with simultaneous extreme-ultraviolet images. They found that many of these bright regions coincide with small, bright features known as coronal bright

points, which are formed by small-scale magnetic loops and are commonly found within polar coronal holes. In several cases, the bright regions were also linked to coronal jets, indicating continuous small-scale magnetic activity in the Sun's polar atmosphere.

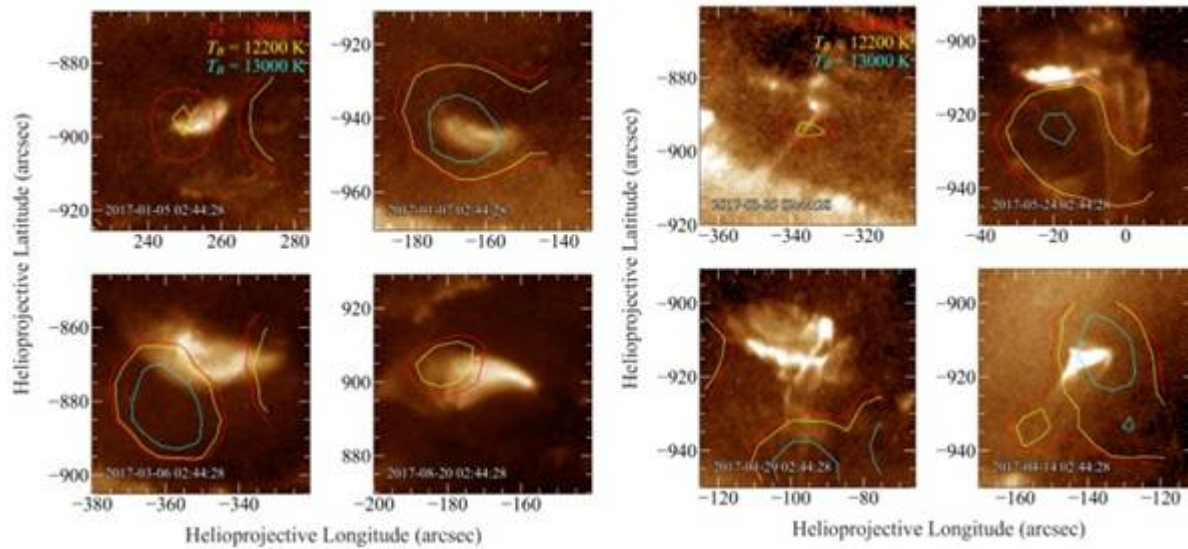


Fig 3: Examples of microwave bright patches observed within polar coronal holes. Many of these brightenings are associated with coronal bright points (left) and coronal jets (right) seen in extreme-ultraviolet observations.

The findings published in the *Astrophysical Journal*, indicate that both large-scale and small-scale magnetic processes influence microwave polar brightening. While the overall brightness variation tracks the evolution of the polar magnetic field and coronal holes, localized brightening is often associated with compact magnetic structures and jet activity within these regions. These findings provide strong observational evidence that microwave polar brightening is governed by the evolution of the Sun's polar magnetic environment and highlight the importance of radio observations for understanding solar polar activity and the origin of the solar wind.

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