

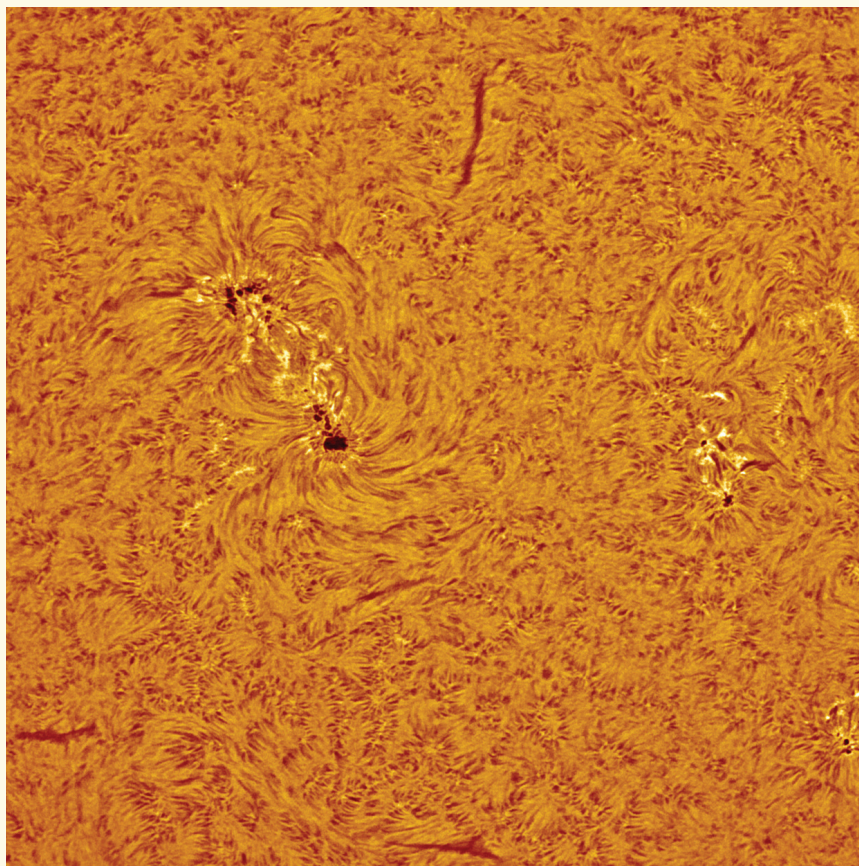
Slow solar wind traced to Sun's active regions

Multifaceted observations of the Sun reveal that interactions between magnetic field loops expel slow-moving solar wind.

Solar wind can be either fast or slow. Fast solar wind can flow more than 500 km/s, and its origins in the corona are relatively well understood. Slow solar wind is highly variable, and heliophysicists have debated where it originates in the Sun's atmosphere. By the time slow solar wind reaches Earth, it becomes difficult to resolve the slight variations in its chemical composition and thus more difficult to trace its specific solar source region. For the past two years, NASA and the European Space Agency's *Solar Orbiter* has been moving around the Sun, and it's been getting close enough to study solar wind in greater detail.

Now Stephanie Yardley of Northumbria University in the UK and colleagues have used multiple *Solar Orbiter* instruments to explore the origins of slow solar wind. Positioned about 0.5 AU away from the Sun in March 2022, the spacecraft took high-resolution images of the star's active regions. (Past analyses studied the wind at 1 AU.) It collected more data as the wind passed by the spacecraft a few days later. The short time delay meant that there was minimal loss in detail between the two measurements. Yardley and colleagues then used spectroscopic techniques to measure the composition of the wind—for instance, the iron-to-oxygen line ratio—and match it to areas of similar composition on the Sun.

Fast solar wind has already been linked to coronal holes—dark regions seen in extreme UV light in the corona. Yardley and colleagues traced the slow solar wind to an active region complex that consists of two active regions with both open and closed magnetic field loops; it is adjacent to a coronal hole with many open magnetic field loops. The proximity between a coronal hole and an active region complex provides a favorable configuration for the mechanism by which the solar wind is expelled.

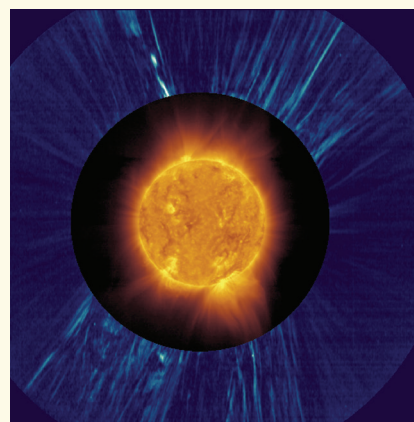


THE SUN'S SURFACE is covered in splotches: sunspots and active regions with curving filaments. The active regions are theorized to emit slow solar wind. (Image by ESA/ESAC/CESAR—A. de Burgos.)

Closed magnetic field loops in coronal regions are known to have plasma flowing along them, but nothing escapes. For plasma to be expelled from closed loops, they need to interact with adjacent open loops. The *Solar Orbiter* instruments that measure solar wind plasma and magnetic fields were able to gather evidence that the interaction between the two loop types in neighboring solar regions is what gives rise to the slow solar wind.

Yardley and her team are working on a more complex analysis for subsequent close *Solar Orbiter* approaches and on incorporating data from other missions, including the *Parker Solar Probe* (see the article by Nour E. Raouafi, *PHYSICS TODAY*, November 2022, page 28). Future observations should deepen our understanding of what causes the variability in the wind and its origins, which will ultimately allow for better predictions of space weather. (S. L. Yardley et al., *Nat. Astron.*, 2024, doi:10.1038/s41550-024-02278-9.)

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THE SUN as seen by the *Solar Orbiter* spacecraft on 25 March 2022. The inside image is of the solar surface; the outer image shows the corona. The prominent light-blue feature at the roughly eight o'clock position in the corona can be traced to an active region on the Sun's surface where magnetic field lines are interacting. (Image by ESA and NASA/*Solar Orbiter*/EUI and Metis Teams and D. Telloni et al., 2022.)