VOL. 97 • NO. 19 • 1 OCT 2016

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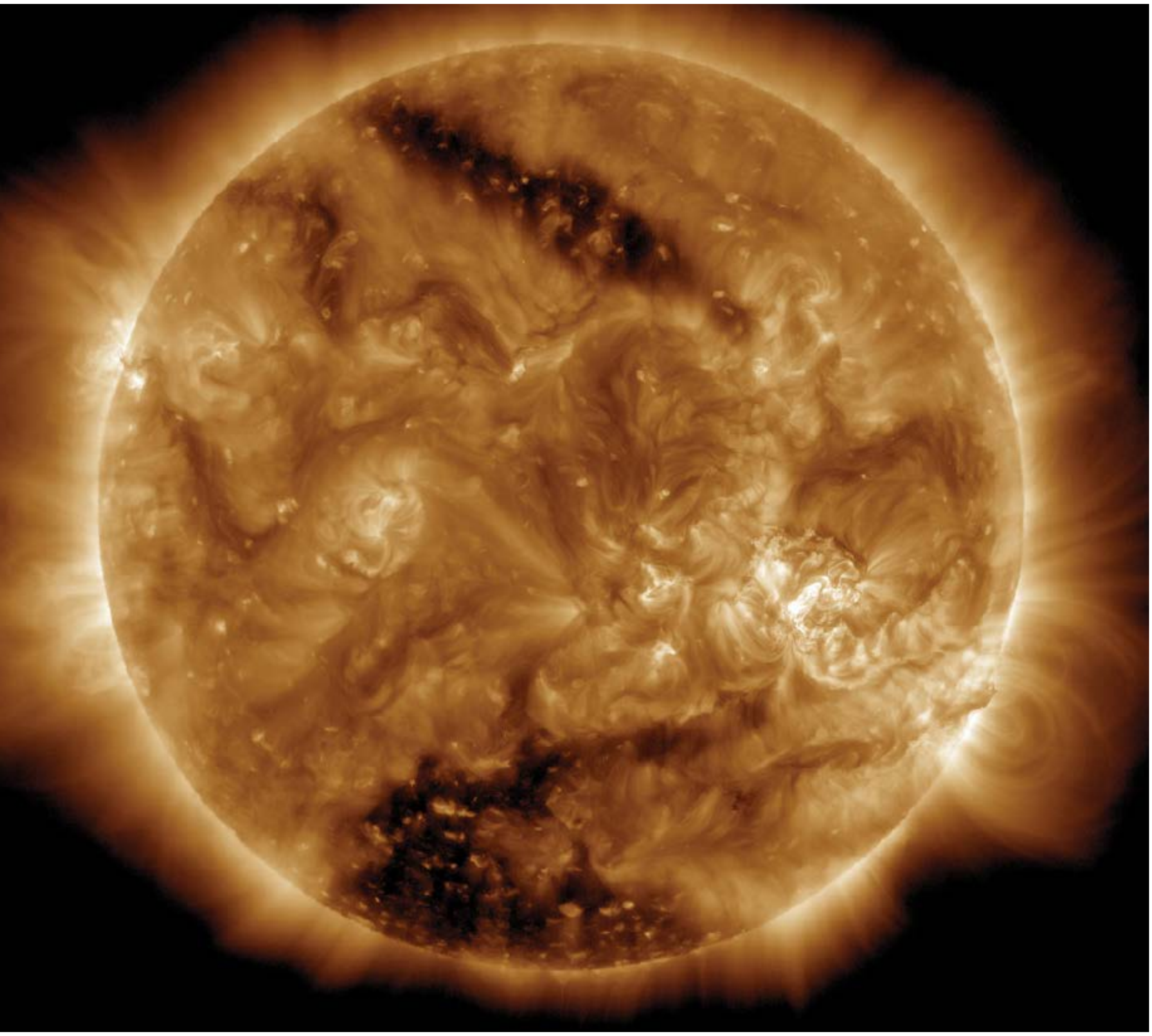
Spotting the Source of Slow Solar Wind



Coronal holes, like the one pictured here at the southern pole of the Sun, are a source of fast solar wind; the source of slow solar wind has been harder to trace.

The surface of the Sun is a hotbed of activity. The outer layer of the Sun, known as the corona, can reach a few million degrees Celsius, spewing a hot gas of protons, electrons, and other trace elements out into space. The escaping plasma and particles are called solar wind. Fast solar wind, which can reach speeds in excess of 500 kilometers per second, emerges from the center of coronal holes—dark spots on the surface where the Sun's magnetic field lines open up and extend out into space, providing an escape route for the hot gas. The origin of slow solar wind, however, has proven more difficult to uncover. To help zero in on its source, *Kepko et al.* took a look at data gathered as slow solar wind swept past several near-Earth spacecraft.

Previous research has given rise to three general models for slow solar wind: The expansion factor model predicts that slow wind emanates from the tubelike stretch of space containing the magnetic field as it peels off into space away from the Sun at the edges of coronal holes; the interchange model suggests that the wind comes from the intact corona, spurred by the collision and realignment of magnetic field lines, or magnetic reconnection; and the S-Web model is somewhere between the two, with the solar wind fueled by magnetic reconnection and emanating from the boundaries of coronal holes.

To trace the wind's origin, the scientists looked at its charge state ratios and elemental composition, which can serve as a fingerprint for the conditions that produce solar wind. Using measurements of charge state abundance and composition measurements at 12-minute intervals made by the Advanced Composition Explorer (ACE) and Wind spacecraft, the team found that the plasma measurements fluctuated on roughly 90-minute cycles, a finding in agreement with previous research on charge state and composition variability.

The authors discovered that the charge state and composition properties of the slow wind oscillated in regular, nonrandom patterns between measures typical of slow wind and those typical of fast wind. Proton density within the plasma became 3 times higher by the midpoint of the cycle before dropping down again, whereas the helium, carbon, and oxygen abundances peaked late in the 90-minute cycle. This pattern of variability suggested that the charge state and composition of slow wind are imbued in the wind as it originates in the solar atmosphere and not in transit.

These findings hint at a potential slow solar wind source. Only magnetic reconnection at the Sun's surface could cause the wind to have charge state and compositional properties characteristic of both fast and slow wind. The lack of relationship between the velocity of the wind and its composition revealed in the study would not be predicted by the expansion and interchange models.

The results provide strong evidence for a magnetically driven slow wind source, which could eventually help researchers better predict solar wind phenomena and protect infrastructure and operations on Earth from the effects of space weather. (*Geophysical Research Letters,* doi:10.1002/2016GL068607, 2016)

—Kate Wheeling, Freelance Writer