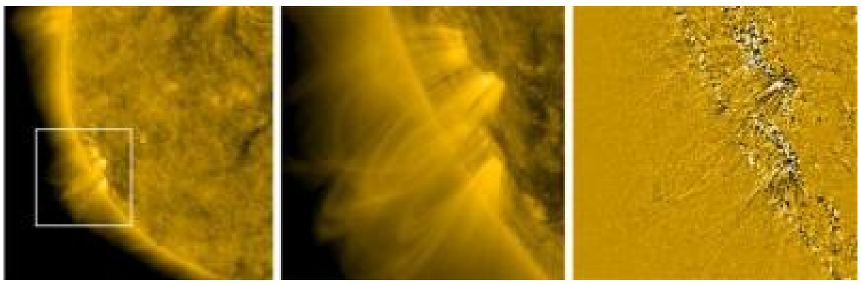
Plasma jets are prime suspect in solar mystery

January 6 2011



At left: Portion of the "solar disk," the face of the Sun pointed towards Earth, as viewed by NASA's Solar Dynamics Observatory satellite on the morning of April 25, 2010. Center: A closeup of the "solar limb," showing the area outlined in the lefthand image, including the solar corona (outer atmosphere). Right: The same area of the limb, with white and black areas indicating motion. Spicules themselves are so faint that scientists use images like this to see disturbances associated with the spicules where they are emerging (in white) and where they have just been (in black). The spicules streak upward from the solar surface at speeds often greater than 100 kilometers per second (60 miles/sec). Some of the spicules' plasma (ionized gas), at temperatures in excess of one million degrees kelvin, flows up into the corona. (Images courtesy NASA's Solar Dynamics Observatory, Atmospheric Imaging Assembly.)

(PhysOrg.com) -- One of the most enduring mysteries in solar physics is why the Sun's outer atmosphere, or corona, is millions of degrees hotter than its surface. Now scientists believe they have discovered a major source of hot gas that replenishes the corona: narrow jets of plasma, known as spicules, shooting up from just above the Sun's surface. The finding addresses a fundamental question in astrophysics: how energy moves from the Sun's interior to create its hot outer atmosphere.

"It's always been quite a puzzle to figure out why the Sun's atmosphere is hotter than its surface," says Scott McIntosh, a scientist at the National Center for Atmospheric Research (NCAR), a coauthor of the study. "By identifying that these jets insert heated plasma into the Sun's outer atmosphere, we gain a greater knowledge of the corona and possibly improve our understanding of the Sun's subtle influence on Earth's upper atmosphere."

The new study, published this week in the journal *Science*, was conducted by scientists from Lockheed Martin's Solar and Astrophysics Laboratory (LMSAL), NCAR, and the University of Oslo. It was supported by NASA and the National Science Foundation, NCAR's sponsor.

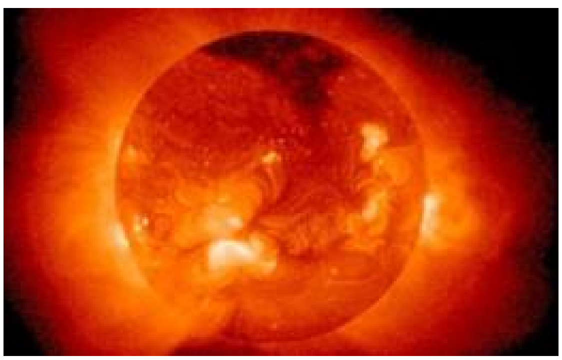
Delivering heat to the Sun's corona

The research team focused on spicules, which are fountains of plasma propelled upward from near the surface of the Sun into its outer atmosphere. For decades scientists thought that spicules might be sending heat into the corona. However, following observational research in the 1980s, it was found that spicule plasma did not reach coronal temperatures, and so this line of study largely fell out of vogue.

"Heating of spicules to millions of degrees has never been directly observed, so their role in coronal heating had been dismissed as unlikely," says Bart De Pontieu, the lead author and a solar physicist at LMSAL.

In 2007, De Pontieu, McIntosh, and their colleagues identified a new class of spicules that moved much faster and were shorter lived than the traditional spicules. These "Type II" spicules shoot upward at high speeds, often in excess of 60 miles per second (100 kilometers per second), before disappearing. The rapid disappearance of these jets suggested that the plasma they carried might get very hot, but direct observational evidence of this process was missing.

In the *Science* paper, the researchers used new observations from the Atmospheric Imaging Assembly on NASA's recently launched Solar Dynamics Observatory and NASA's Focal Plane Package for the Solar Optical Telescope (SOT) on the Japanese Hinode satellite.

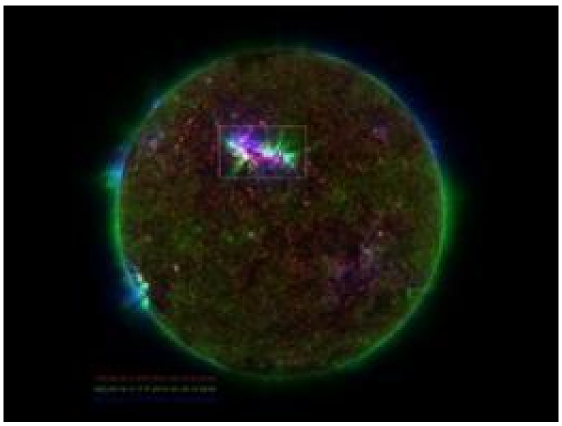


Jets of plasma from just above the Sun's surface likely replenish its corona. Credit: NASA

"The high spatial and temporal resolution of the newer instruments was crucial in revealing this previously hidden coronal mass supply," says McIntosh, a solar physicist at NCAR's High Altitude Observatory. "Our observations reveal, for the first time, the one-to-one connection between plasma that is heated to millions of degrees kelvin and the spicules that insert this plasma into the corona."

Looking toward the interface

The findings provide an observational challenge to existing theories of coronal heating. During the past few decades, scientists have proposed a wide variety of theoretical models, but the lack of detailed observation has significantly hampered progress. "One of our biggest challenges is to understand what drives and heats the material in the spicules," says De Pontieu.



Spicules on the sun, as observed by the Solar Dynamics Observatory. These bursts of gas jet off the surface of the sun at 150,000 miles per hour and contain gas that reaches temperatures over a million degrees. Credit: NASA Goddard/SDO/AIA

A key step, according to De Pontieu, will be to better understand the interface region between the Sun's visible surface, or photosphere, and its corona. Another NASA mission, the Interface Region Imaging Spectrograph (IRIS), is scheduled for launch in 2012. IRIS will provide high-fidelity data on the complex processes and enormous contrasts of density, temperature, and magnetic field between the photosphere and corona. Researchers hope this will reveal more about the spicule heating and launch mechanisms.

More information: The origins of hot plasma in the solar corona, B. De Pontieu, S.W. McIntosh, M. Carlsson, V.H Hansteen, T.D. Tarbell, P. Boerner, J. Martinez-Sykora, C.J. Schrijver, *Science*, January 7, 2011

Provided by National Center for Atmospheric Research