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EDITORS: Elena Benevolenskaya will present the paper, "Solar Cycle Variations in Corona," at the American Astronomical Society meeting in Albuquerque, NM, on June 5, at 10 a.m. MDT. Photos, graphics and videos can be downloaded at http://soi.stanford.edu/press/aas06-02.

EMBARGOED UNTIL WEDNESDAY, JUNE 5, AT 10 A.M. (U.S. Mountain Daylight Time)

Relevant Web URLs:
http://science.msfc.nasa.gov/ssl/pad/solar
http://soi.stanford.edu/press/aas06-02
http://www.aas.org/meetings/aas200/program/

GIANT LOOPS IN THE SOLAR ATMOSPHERE MAY TRIGGER SUN'S MAGNETIC POLES REVERSALS, NEW STUDY REVEALS

New findings by Stanford astronomers may help solve one of the most baffling questions in solar science: What causes the Sun's magnetic poles to flip-flop every 11 years?

Understanding the forces that drive this 11-year cycle could help researchers predict violent solar flares and eruptions that periodically interfere with communications on Earth, said Elena E. Benevolenskaya, a physical science research associate at Stanford's W.W. Hansen Experimental Physics Laboratory (HEPL).

"One of the main problems for astronomers in the last century has been finding a mechanism strong enough to cause polar reversals," she noted.

After analyzing a decade's worth of satellite data, Benevolenskaya and her colleagues may have found a crucial part of that mechanism – giant loops of hot, electrified gas that link the Sun's magnetic poles to sunspots located near the solar equator.

Each loop is like a colossal, twisted rainbow – a 500,000-mile-long arc that extends into the Sun's outer atmosphere, or corona, then returns to the surface. One end of the loop runs through either the north or south magnetic pole. The other end is connected to a sunspot of opposite magnetic polarity.

The giant loops are formed by intense magnetic fields that are potentially strong enough to trigger polar reversals, according to Stanford researchers. The magnetic fields probably originate in the "solar dynamo" – a region located 135,000 miles below the surface, which scientists believe is the source of all magnetism in the Sun.

Solar cycle

Benevolenskaya presented these findings at the June 5 meeting of the American Astronomical Society (AAS) in Albuquerque, NM. The results also appear in the current issue of AAS' *Astrophysical Journal Letters* in a study co-authored by Stanford physicists Alexander G. Kosovichev and Phillip H. Scherrer; and J. R. Lemen and G. L. Slater of the Lockheed Martin Solar and Astrophysics Laboratory in Palo Alto, CA.

"Like Earth, the Sun has magnetic poles," Kosovichev said, "but unlike Earth, the Sun's polarity is not constant. It changes every 11 years from magnetic north to magnetic south and back. However, the origin of these periodic reversals is unknown."

Earlier studies showed that polarity reversal occurs at the middle of the 11-year cycle – a period known as the "solar maximum," when the number of sunspots are at their peak. Scientists believe that sunspots – which are often accompanied by solar flares and explosions – result when pent-up magnetic fields generated in the dynamo finally break through the surface.

Following solar maximum, the number of sunspots gradually decreases until they all but disappear approximately five years later – a period known as the "solar minimum," when the surface of the Sun is relatively inactive.

"The last solar maximum occurred in 2000, and we're heading toward another minimum in 2006," Kosovichev noted.

To get a clear picture of how solar magnetic fields behave during a typical 11-year cycle, the Stanford team analyzed data collected between 1991 and 2001 from two orbiting satellites – Yohkoh, launched by Japan's Institute for Space and Astronautical Sciences; and SOHO, the Solar and Heliospheric Observatory operated by NASA and the European Space Agency (ESA).

The satellite data covered the declining phase of the previous solar cycle, from the 1991 maximum to the 1996 minimum; as well as the rising phase of our present cycle – 1997 to 2001.

The giant coronal loops are filled with gas particles heated to 3.5 million degrees Fahrenheit – a temperature hot enough to emit high-energy X-rays, which are invisible to the human eye. Yohkoh – Japanese for "sunbeam" – carries a telescope on board capable of "seeing" the X-ray emissions and translating them into remarkable pictures. These X-ray images, along with ultraviolet and magnetic data from the SOHO satellite, confirmed the existence of the loops.

Sunspot behavior

"Sunspots do not occur randomly," Scherrer noted. "They are concentrated above and below the solar equator."

Spots that appear in the northern hemisphere are mirrored by spots in the southern hemisphere, he added.

Most sunspots occur in pairs – a leading spot, which carries the same magnetic polarity as the magnetic pole; and a trailing spot, which has the opposite charge. For example, if the Sun's north magnetic pole is positive ("+"), then all leading spots north of the equator will be positive ("+") and all trailing spots will be negative ("-").

According to satellite data, the giant loops observed in the study only formed connections between magnetic poles and trailing spots located in the same hemisphere.

"These loops never crossed the equator," Scherrer said.

Because the magnetic pole and the trailing spot carried opposite magnetic polarities, each loop generated an incredibly intense flow of electricity. As the 2000 solar maximum approached, the number of trailing sunspots and loops increased – creating numerous magnetic links that may have been strong enough to contribute to the magnetic pole reversal.

"We believe these direct magnetic links can accelerate the process of the polar field reversal and create the starting conditions for the next solar cycle, " Kosovichev explained.

Flares, coronal mass ejections and other solar activity can disable satellites and wreak havoc on Earth – producing widespread power outages and interrupting vital radio communications. Therefore, predicting when solar activity will occur is a major objective for researchers, Kosovichev said.

Mysterious cycle

Satellite data also revealed that the giant loops underwent a mysterious pattern of growth and development.

"The loops only appeared when there were bursts of sunspot activity, which came every 12 to 18 months during the rising phase of the 11-year cycle," Benevolenskaya noted.

This strange 12-to-18-month cycle could have its origins in the solar dynamo inside the Sun. Two years ago, Stanford researchers discovered that two parallel layers of gas deep beneath the surface were mysteriously speeding up and slowing down every 12 to 16 months. Researchers suspect that these rotating gas layers are part of the solar dynamo that generates the Sun's awesome magnetic fields.

"Our research confirms a remarkable order and synchronization in the magnetic polarities of sunspots and magnetic poles," Kosovichev concluded. "These results also may lead to new ideas about the active role that the solar corona plays in generating sunspot cycles."

Stanford's solar research is supported by NASA and ESA through the SOHO satellite mission. Although technical problems caused Yohkoh to stop functioning last December, the SOHO satellite continues to provide data to scientists at Stanford and other institutions around the world.

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-By Mark Shwartz-