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Scientists from NASA's Jet Propulsion Laboratory and the European Space Agency are reporting the first observations ever made in the Sun's polar regions at today's meeting of the American Geophysical Union in San Francisco.

"A number of longstanding questions have been answered in exploring this region of the Sun, but, as usual, there have been major surprises," said Dr. Edward J. Smith, NASA project scientist at the Jet Propulsion Laboratory, who is participating in today's press conference, along with Dr. Richard Marsden, ESA project scientist, and two of the Ulysses science experiment principal investigators.

"The gas being continuously carried by the Sun's solar wind has been found to be a very fast and relatively smooth flow," Smith said in characterizing the polar environment from Ulysses data. "Surprisingly, the strength of the Sun's magnetic field over the poles is the same as it is near the equator. Large amplitude magnetic waves are continuously present in the polar regions. And the intensity of cosmic ray particles arriving from the galaxy is only slightly larger than near the Sun's equator."

These and other findings were made possible by the Ulysses mission, an international collaboration between the American and European space agencies. The Ulysses spacecraft finally reached the Sun's south pole this past summer after a journey of almost four years. It took this long because no existing rocket is powerful enough to break free of Earth's gravity and send a spacecraft directly over the Sun's poles. The spacecraft, which was launched on October 6, 1990, had first to travel outward to Jupiter, arriving on February 8, 1992, and use Jupiter's gravity field to redirect its flight path toward the Sun's poles. The Ulysses trajectory is such that, at the time of the polar passage, the spacecraft was more than twice as far from the Sun as the average distance from the Sun to the Earth. Consequently, although Ulysses is the first spacecraft to probe the Sun's polar regions, it does not travel near the Sun.

The team of scientists led by Dr. John Phillips of Los Alamos National Laboratory reported that near the pole the solar wind is flowing away from the Sun at nearly twice the speed that is typically observed near the Sun's equator and that is continuously arriving at Earth. The solar wind flow is also much smoother than at low latitudes, causing a marked reduction in the "space weather" that typically exists near the equator and which affects the Earth by causing magnetic "storms" and the aurora borealis, or northern lights.

"The solar wind comes from the Sun's outermost atmospheric region, the corona," Phillips said. "The corona is so hot that it consists only of negatively charged electrons and the positively charged atoms (ions) from which they have been removed. The speed of these hot electrons and ions is so great that even the strong gravity field of the Sun cannot prevent their escape into space."

As they leave the Sun, however, the heat energy of these electrons and ions is converted into a high speed flow by a process that is analogous to that which takes place inside a rocket engine. Scientists now expect to take advantage of the simplicity of the solar wind flow in the polar regions to better understand the physical conditions under which the solar wind originates, Phillips said. Such knowledge should also clarify the high speed emission of gas from other stars, known as the stellar winds, which is thought to be commonly occurring throughout the universe.

Scientists had expected to see the magnetic fields embedded in the solar wind increase in strength as Ulysses traveled toward the pole, but there were more surprises awaiting them. The solar wind fields bear the imprint of magnetic fields originating on the Sun, which increase in strength toward the poles, just like the magnetic field of the Earth. Surprisingly, however, Ulysses's observations have not revealed the expected increase from the equator to the poles.

The scientific team, headed by Dr. Andre Balogh of Imperial College, London, interpreted this finding to mean that the magnetic fields in the Sun's polar region are pushing the solar wind toward the equator to produce a field whose strength does not depend on latitude. Consequently, the magnetic field must be exerting a much stronger influence on the solar wind near the Sun than had previously been thought. The mathematical models used by scientists to relate the Sun's fields to those carried off by the solar wind must now be reconsidered.

Another major result involving magnetic fields is the continual presence in the polar cap of very strong waves. The waves cause changes in the magnetic field that are comparable to the field strength so that the field direction varies continuously through large angles. The waves are considered to be an important aspect of the solar wind flow and may contribute to the heating and speeding up of the solar wind. In addition, the waves, which are traveling outward from the Sun, are thought to be opposing the entry of the electrically charged cosmic ray particles into the polar regions. The waves are similar to those that can be produced on Earth by wiggling the free end of a rope that is attached to a post at the other end. A possible explanation of the magnetic waves is that the ends of the magnetic line of force attached to the Sun are being subjected to churning motions of the Sun's surface; the motions themselves resemble those seen in a bowl of porridge on a hot stove.

"Waves of this kind have previously been observed sporadically by spacecraft observing the solar wind in the vicinity of Earth," Smith said. "The waves accompany high speed solar wind, which can also be present for several days at a time. The presence of the waves has been shown to produce a high intensity, long-lasting polar aurora."

As a result of Ulysses's observations, it is now believed that during such episodes the Earth is temporarily immersed in solar wind from the Sun's polar regions, which is also characterized by high speed and the presence of waves. Thus, Ulysses has found a direct physical connection between the polar caps of the Sun and the Earth.

Scientists had speculated for many years that the Sun's poles form a "funnel" that allows easy access to the inner solar system of cosmic ray particles. If this were true, a large increase in the particle intensity should have been recorded as Ulysses traveled poleward. However, measurements reported by Professor J.A. Simpson of the University of Chicago, who heads the cosmic ray science team, show only a slight increase in intensity. Consequently, the funnel is non-existent.

"Cosmic rays are the nuclei of atoms from which all electrons have been removed," Marsden, ESA project scientist, said. "They are created in cataclysmic events occurring elsewhere in the galaxy and reach the vicinity of the Sun traveling at nearly the speed of light. They tend to travel along lines of magnetic force. It was anticipated that they could travel along radial solar wind magnetic fields into the polar region. But, in fact, the supposed funnel is caused by the diverging shape of the Sun's polar cap magnetic fields."

However, the strong waves being reported by the Ulysses magnetic field investigators are now thought to be deflecting the cosmic rays back into space, thereby acting as a baffle that is overcoming the focusing effect of this so-called funnel, Marsden added.

Ulysses is now leaving the south polar region of the Sun and is heading back toward the Sun's equator and the ecliptic plane in which Earth orbits the Sun. The spacecraft will then begin to travel northward along its trajectory to begin exploring the Sun's north polar cap beginning in June 1995.

Ulysses is managed jointly by NASA and the European Space Agency to study the regions above the Sun's poles. The Jet Propulsion Laboratory manages the U.S. portion of the mission for NASA's Office of Space Science, Washington, D.C.

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