Unruly Sun emerges from Solar Space Observatory SOHO

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In praise of the sun the Rig Veda states, "Sustainer of the Heaven, Lord of the cosmos, this sage puts on his golden coloured mail ... Maintaining his own laws he runs his course." And today in the space age, even with modern spacecraft technology, the sun remains a mysterious object from the scientific viewpoint. Nevertheless, proximity of the sun to the earth makes it the only star among the billions of stars in the sky available for detailed examination by telescopes. All other stars appear as blobs of light, or at best, with modern interferometry, as mottled discs. As a source of light and life to the entire solar system including our own planet, the sun serves as the 'Rosetta Stone' for astrophysics.

In a major effort by ESA and NASA, a new solar space observatory SOHO (Solar and Heliospheric Observatory) was launched on December 2, 1995 to study the sun from its deep interior to its extensive outer atmosphere. Stationed in space, some 1.5 million kilometers away from us where the gravitational pulls of the sun and earth are in balance, the spacecraft has been returning the sun's glare with a steady gaze of its own since early 1996. Like nearly all efforts to study the sun, the $ 1.2 billion spacecraft with twelve sophisticated instruments on board, has been providing unprecedented clues to the nature of the sun's million-degree-temperature corona (the sun's halo of ionized gases), the solar wind and the conditions deep inside the sun (by making hi-fi recordings of the sun's strange song using the techniques of helioseismology).

The sun is the dynamo, the energy generator, of the solar system. The sunlight, shining on our planet, provides heat for the atmosphere, drives the weather, and makes life possible. However, the sun in X-rays and EUV (extreme-ultraviolet) light appears completely different from the sun we see in the sky. Only very hot gases can emit X-rays and EUV. The sun's corona, at a million of degrees, is hot enough to emit X-rays or EUV, while the much cooler face of the sun (invisible light), at 6000 degrees, is not. In the corona, the shape and character of the hot gases are controlled by the solar magnetic fields, just as beads move with the string upon which they are threaded. In addition to electromagnetic radiation, the sun produces *the solar wind*. The solar wind is composed of charged particles, ions and electrons, which continuously stream out from the sun with velocities over 400 kilometers per second. Although the velocity is very high, the density of the wind is many millions of times lower than the atmospheric density at the earth's surface. If we were to go into space and put our hands in this wind, we would not even be able to feel it.

Two main scientific goals of the SOHO mission are to address such unanswered questions as: what heats the corona to million

degree temperature when the sun's face is a mere 6000 degrees?, and what propels the solar wind? And SOHO's imaging instruments have already yielded surprises. The spectacular pictures taken by the Extreme-ultraviolet Imaging telescope (EIT) on board SOHO show the sun's violent atmosphere. These images reveal that even in its current lull of activity, the sun is unexpectedly turbulent. It sparkles like a diamond in these images. Short, hair-like jets of strong emissions decorate the sun's atmosphere to an extent not seen before. These 'spicules' of various kinds suggest the energetic upheavals that may be responsible for heating the outer atmosphere to millions of degrees. Also visible in the ultraviolet images are plumes like ropes, stretching far into space from the north and south poles of the sun.

Observations from SOHO dispel the view that the lulls in the eleven-year cycle of the solar activity are periods of real calm. SOHO's visible-light coronagraph LASCO (this device images the corona by blocking the sun's disc thus simulating an eclipse) has observed enormous eruptions from the sun's atmosphere that jettison billions of tonnes of gas into space at speeds of hundreds of kilometers per second. Such eruptions are familiar at the sun's activity peaks. But now it seems that even at the solar minimum, the solar magnetic field is extremely active. Such events disturb the whole solar system and affect the earth's own space environment.

One of the other exciting observations from the SOHO's Ultraviolet Coronagraph Spectrometer (UVCS) is the detection of 100 million degree oxygen ions in the sun's atmosphere. This temperature is tens of times higher than has ever been measured before in the corona. It is hundred times hotter than the temperature of electrons in the same part of the corona. The findings are all the more surprising because they turned up in what was thought to be a cool spot, a *coronal hole*. A coronal hole is a region of the corona where the sun's magnetic field lines wander into space rather than arching back to its surface. Coronal holes look dark in EUV and X-ray images of the sun because the free electrons there are cooler and densities lower than elsewhere. The detection of superhot oxygen seems to provide crucial support for theories that may solve long lasting riddles of the sun, the existence of the corona and the acceleration of the solar wind.

First results from SOHO are amazingly fascinating. SOHO's uninterrupted observations (currently taken 24 hours a day and 7 days a week) present us with enormous data of high quality, never obtained before. SOHO scientists are at work decoding them and pointing their instruments to collect more coded messages from the sun. SOHO's results present an excellent promise to solve some of the puzzles about the sun. And as the Rig Veda states, " . in tune with his own being he sings the hymn", the enthralled SOHO scientists have only just started decoding the sun's hymn in its scientific perspective.

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