STEREO Reveals the Anatomy of a Solar Storm in 3D

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(PhysOrg.com) -- Observations from NASA's twin Solar Terrestrial Relations Observatory (STEREO) spacecraft have allowed scientists to reveal for the first time the speed, trajectory, and three-dimensional shape of solar explosions known as coronal mass ejections, or CMEs.

CMEs are powerful eruptions of plasma and magnetic energy from the sun's outer atmosphere, or corona. When these sudden outbursts are directed toward Earth, they can have both breathtakingly beautiful and potentially damaging effects.

"We can now see a CME from the time it leaves the solar surface until it reaches Earth, and we can reconstruct the event in 3D directly from the images," said Angelos Vourlidas, a solar physicist at the Naval Research Laboratory, and project scientist for the NRL-led Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) aboard STEREO.

The NRL team has always been a leader in CME research, beginning with their initial discovery by an NRL-built telescope in 1971 (OSO-7). The CME phenomenon was explored in more detail by another NRL-led experiment (P78-1/Solwind) in the 1980's, resulting in the discovery of the characteristic signature (a halo) of Earth-directed CMEs, as well as the association to interplanetary shocks. Then in 1995, the NRL-led LASCO experiment was launched, with greatly increased sensitivity enabling routine observations of Earth directed CMEs, firmly establishing the solar origin of space weather events.

"The evolution in imaging capability since the discovery in 1971 to now is just astounding. It took 44 minutes to read out the 256x256 pixel image (worse than most cell phone images), whereas now it takes a few seconds to read out the current 2048x2048 pixel image.", said Russ Howard a solar physicist at NRL, and principal investigator of the LASCO and SECCHI experiments.

Until now, CMEs were observed near the sun but the next measurements had to wait until the CME arrived at Earth three to seven days later. STEREO's ability to continuously image a CME from its explosive birth to arrival at Earth is the first time this has been achieved and represents a significant advance. 3D tracking of an evolving CME is critical to determining its structure and predicting if and how it will affect Earth.

STEREO consists of two nearly identical observatories that make simultaneous observations of CMEs from two different vantage points. One observatory "leads" Earth in its orbit around the sun, while the other observatory "trails" the planet. "The larger the separation between the spacecraft, the larger the structures we can examine," said Vourlidas.

Using the SECCHI telescopes, solar physicists can examine a CME's structure, velocity, mass, and direction in the corona and track it through interplanetary space. Such measurements can help determine when a CME will reach Earth, at what speed, and how much energy it will deliver to Earth's magnetosphere.

CMEs carry billions of tons of plasma into space at thousands of miles per hour. This plasma - which carries some of the magnetic field from the corona with it - can create a large, moving disturbance in space that also produces a shock wave. The shock can accelerate some of the surrounding particles to high energies, a form of "solar cosmic rays" that can be hazardous to spacecraft and astronauts. The shock and CME material, which arrive days later, can produce disruptive space weather

during and following their interaction with Earth's magnetosphere and upper atmosphere.

The seriousness of the effects depends on the size and speed of the CME when it arrives at Earth. These sun storms can interfere with communications between ground controllers and satellites, pilots flying near Earth's poles, and astronauts on the International Space Station. Radio noise from the storm can also disrupt cell phone service. Disturbances in the ionosphere related to CMEs can affect Global Positioning System (GPS) navigation and, in extreme cases, induced currents in long cables and transformers on the ground can cause power outages.

The twin STEREO spacecraft were launched October 25, 2006 into Earth's orbit about the sun. The STEREO mission employs two nearly identical observatories to provide 3-D measurements of the sun to study the nature of coronal mass ejections. STEREO is the third mission in NASA's Solar Terrestrial Probes program (STP).

Video: www.nrl.navy.mil/PressReleases … ovies/conceptual.swf

Provided by Naval Research Laboratory (news : web)