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The STEREO Mission: A Three-Dimensional View of the Sun and Heliosphere

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Coronal Mass Ejections: Coronal mass ejections (CMEs) are massive outflows of material from the Sun's corona, traveling into the surrounding heliosphere at speeds up to 1000–2000 kilometers per second. When directed toward the Earth, CMEs can result in damage to satellites, enhanced auroral displays, blackouts of power grids on Earth, and interference with surface radio communications. The first CME detected from space was observed by an NRL coronagraph onboard the Seventh Orbiting Solar Observatory (OSO-7) in December 1971.¹

Much of our recent knowledge of CMEs has been obtained from an NRL visible-light coronagraph (LASCO, the Large Angle Spectroscopic Coronagraph²) on the Solar and Heliospheric Observatory (SOHO) spacecraft, launched in 1995. But SOHO observes from only one viewpoint, leaving three-dimensional structure ambiguous for individual CMEs. The next step beyond SOHO is the Solar Terrestrial Relations Observatory (STEREO) mission, consisting of *two* spacecraft observing the Sun from two different viewpoints, allowing a three-dimensional view of the initiation of CMEs and their propagation outwards. In addition, STEREO will carry a new type of heliospheric coronagraph that is off-pointed from the solar disk, and can observe from the side the Sun-Earth line all the way out to Earth. The STEREO mission is meant to increase our understanding of such topics as solar structures and their properties involved in CME initiation; three-dimensional structure and kinematics of CMEs; three-dimensional structure of active regions, coronal loops, and streamers; propagation of CMEs into the corona and interplanetary medium; and the effects of CMEs through the heliosphere to the Earth.

SECCHI Instruments and Their Development: The Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) experiment³ is one component of STEREO. SECCHI was built by an international consortium led by the Naval Research Laboratory. Major components were developed at NRL, Lockheed Martin Solar and Astrophysics Laboratory (Palo Alto, CA), Goddard Space Flight Center (Greenbelt, MD), University of Birmingham (UK), Rutherford Appleton Laboratory (UK), Max-Planck-Institut für Sonnensystemforschung (Germany), Centre Spatiale de Liège (CSL, Belgium), Institut d'Optique (France), and Institut d'Astrophysique Spatiale (France).

Each of the twin SECCHI instrument suites consists of five telescopes. Figure 4 illustrates how each telescope contributes to the total coverage (using existing data from SOHO observations to mimic the SECCHI observations). An extreme-ultraviolet imager (EUVI) will image the solar transition region and low corona, in four emission lines, on the disk and out to 1.7 R_0 (solar radii). The COR1 and COR2 telescopes, visible light Sun-centered coronagraphs with nested fields of view, image the outer corona over 1.4–15 R_0 . They were split into two telescopes for better coverage of the decreasing coronal brightness over this range. The Heliospheric Imager (HI) coronagraph is off-pointed from the solar disk, and can observe from the side a distance range from 15 R_0 out to the radius of Earth at 215 R_0 . Again, coverage is divided between two telescopes, HI-1 and HI-2. A series of linear occulters shelter HI from the glare of the Sun, while internal concentric curved baffles suppress stray light. A Guide Telescope (GT) serves as the spacecraft fine Sun sensor and provides the error signal for the EUVI fine pointing system. The SECCHI Electronics Box (SEB) was developed by the Space Electronics Systems Development Branch at NRL. Figure 5 illustrates the SECCHI instrument suite in the laboratory.

SECCHI went through an instrument development process that included initial design, multiple project reviews, fabrication, integration to two complete packages, and laboratory testing. Characterization of the COR1, COR2, EUVI, and GT was performed at NRL, measuring stray light, spatial resolution, polarization, and photometric response. HI was calibrated at CSL, Belgium. Instrument integration and environmental testing (thermal vacuum, vibration, and electromagnetic interference and compatibility) were performed at NRL using Naval Center for Space Technology facilities prior to spacecraft integration.

Launch and Early Operations: The twin NASA STEREO spacecraft (A and B) were launched on a single Delta rocket from Cape Canaveral on October 25, 2006. Using a lunar encounter, each spacecraft was inserted into an individual final orbit, one spacecraft (B) gradually falling behind Earth in orbit and the other (A) increasingly ahead of Earth. SECCHI first light for each of the A and B telescopes was achieved during the first half of December. Figure 6 illustrates how the scientific observations will be undertaken, showing a simulated Earth-directed CME observed from the A and B spacecraft. The SECCHI COR2A coronagraph already observed its first CME during earliest instrument open-door operations in December 2006.

[Sponsored by NASA and ONR]

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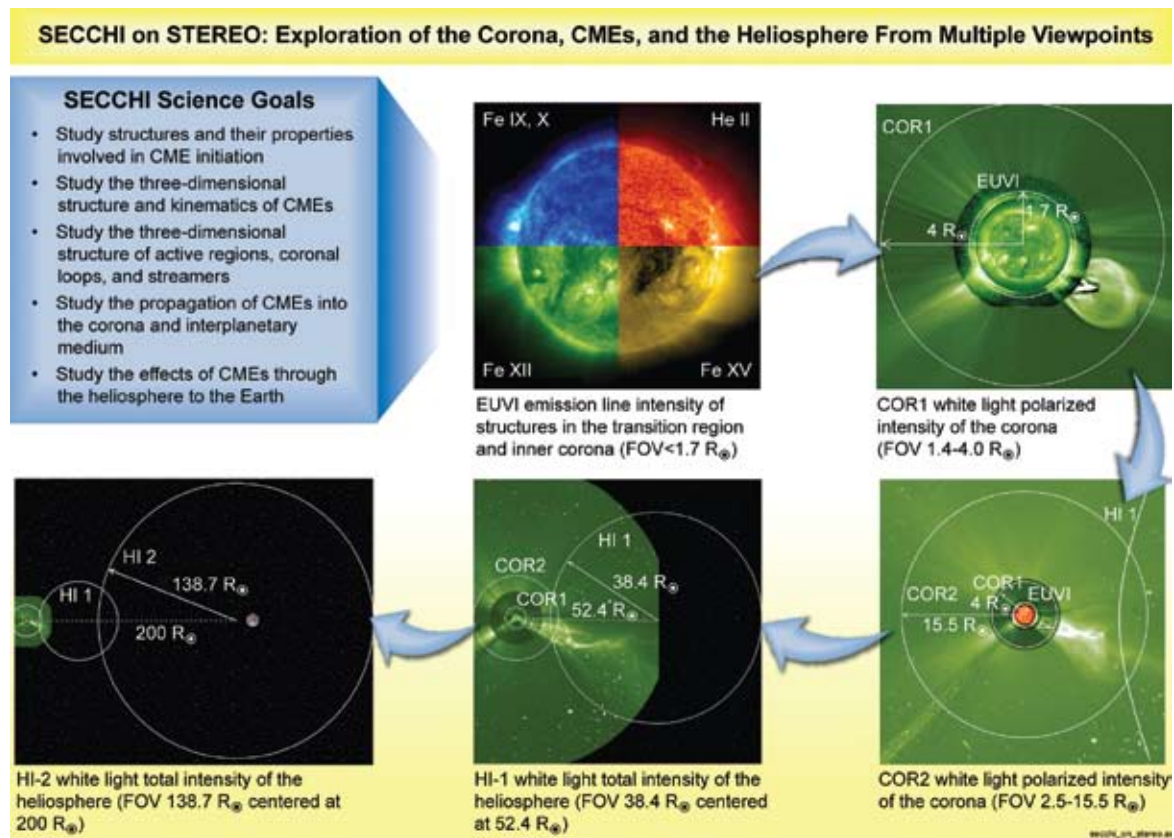


FIGURE 4
SECCHI telescopes and their fields of view.



FIGURE 5
SECCHI instrument suite in the laboratory.

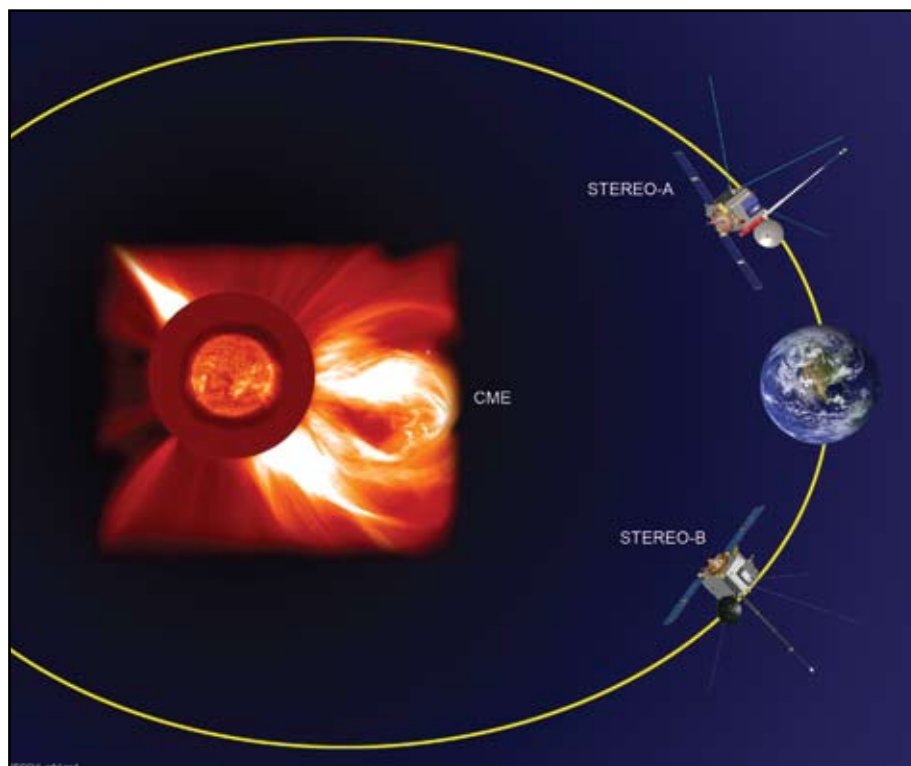


FIGURE 6
The STEREO A and B spacecraft observing an Earth-directed CME.