FACT SHEET

SOHO

Introduction

SOHO, the Solar and Heliospheric Observatory, is a project of international cooperation between ESA and NASA to study the Sun, from its deep core to the outer corona, and the solar wind.

Together with ESA's Cluster mission, SOHO is studying the Sun-Earth interaction from different perspectives.

SOHO's easily accessible, spectacular data and basic science results have captured the imagination of the space science community and the general public alike.

Objectives

SOHO was designed to answer the following three fundamental scientific questions about the Sun:

- What is the structure and dynamics of the solar interior?
- Why does the solar corona exist and how is it heated to the extremely high temperature of about 1 000 000°C?
- Where is the solar wind produced and how is it accelerated?

Clues on the solar interior come from studying seismic waves that are produced in the turbulent outer shell of the Sun and which appear as ripples on its surface.

Science highlights to date

SOHO has provided an unprecedented breadth and depth of information about the Sun, from its interior, through the hot and dynamic atmosphere, to the solar wind and its interaction with the interstellar medium. These findings have been documented in an impressive, still growing body of scientific and popular literature.

Some of the key results include:

- Revealing the first images ever of a star's convection zone (its turbulent outer shell) and of the structure of sunspots below the surface.
- Providing the most detailed and precise measurements of the temperature structure, the interior rotation, and gas flows in the solar interior.
- Measuring the acceleration of the slow and fast solar wind.
- Identifying the source regions and acceleration mechanism of the fast solar wind in the magnetically "open" regions at the Sun's poles.
- Discovering new dynamic solar phenomena such as coronal waves and solar tornadoes.

- Revolutionising our ability to forecast space weather, by giving up to three days notice of Earth-directed disturbances, and playing a lead role in the early warning system for space weather.

- Monitoring the total solar irradiance (the 'solar constant') as well as variations in the extreme ultra violet flux, both of which are important to understand the impact of solar variability on Earth's climate.

Besides watching the Sun, SOHO has become the most prolific discoverer of comets in astronomical history: as of January 2011, more than 2000 comets had been found by SOHO.

Cost

About a thousand million Euros. These costs have been spread between ESA and its member states, and NASA.

Launch

SOHO was launched by NASA on an Atlas II-AS rocket (AC-121) from the Cape Canaveral Air Station (Florida, United States) on 2 December 1995.

Orbit

SOHO moves around the Sun in step with the Earth, by slowly orbiting around the First Lagrangian Point (L1), where the combined gravity of the Earth and Sun keep SOHO in an orbit locked to the Earth-Sun line. The L1 point is approximately 1.5 million kilometres away from Earth (about four times the distance of the Moon), in the direction of the Sun. There, SOHO enjoys an uninterrupted view of our daylight star.

Mission lifetime

SOHO was designed for a nominal mission lifetime of two years. Because of its spectacular successes, the mission was extended five times (in 1997, 2002, 2006, 2008, and 2010). This allowed SOHO to cover an entire 11-year solar cycle (#23) and the rise of the new cycle 24. SOHO is currently approved through the end of 2012.

Control of the spacecraft was lost in June 1998, and only restored three months later through efforts of the SOHO recovery team. All 12 instruments were still us-able, most with no ill effects. Two of the three on-board gyroscopes failed immediately and a third in December 1998. After that, new on-board software that no longer relies on gyroscopes was installed in February 1999. It allowed the spacecraft to return to full scientific operations, while providing an even greater margin of safety for spacecraft operations. This made SOHO the first three-axis stabilised spacecraft operated without gyroscopes, breaking new ground for future spacecraft designs.

Spacecraft

Design

SOHO is a three-axis stabilised spacecraft that constantly faces the Sun. Its design is based on a modular concept with two main elements: the payload module, housing the 12 instrument packages, and the service module, providing essentials such as thrusters, power and communications.

Dimensions

Approximately 4.3 × 2.7 × 3.7 metres (9.5 metres with solar arrays deployed).

Mass

1850 kilograms at launch.

Industrial involvement

SOHO was built for ESA by industrial companies in 14 European countries, led by Prime Contractor Matra Marconi (now Astrium). The service module with solar panels, thrusters, attitude control systems, communications and housekeeping functions, was prepared in Toulouse, France. The payload module carrying the scientific instruments was assembled in Portsmouth, United Kingdom, and mated with the service module in Toulouse. During the building and assembly of the spacecraft, several hundred engineers were employed by the project.

What's on board?

The scientific payload of SOHO comprises 12 complementary instruments, developed and furnished by 12 international consortia involving 29 institutes from 15 countries. Nine consortia are led by European scientists, the remaining three by US scientists. More than 1500 scientists in countries all around the world are either directly involved in SOHO's instruments or have used SOHO data in their research programmes.

Coronal Diagnostic Spectrometer (CDS)
CDS detects emission lines from ions and atoms in the solar corona and transition region, providing diagnostic information on the solar atmosphere, especially of the plasma in the temperature range from 10 000 to more than 1 000 000°C.
Principal Investigator: A. Fludra, Rutherford Appleton Laboratory, Chilton, United Kingdom.

Charge, Element, and Isotope Analysis System (CELIAS)
CELIAS continuously samples the solar wind and energetic ions of solar, interplanetary and interstellar origin, as they sweep past SOHO. It analyses the density and composition of particles present in this solar wind. It warns of incoming solar storms that could damage satellites in Earth orbit.
Principal Investigator: B. Klecker, Max-Planck-Institut für extraterrestrische Physik, Garching, Germany

Comprehensive Suprathermal and Energetic Particle Analyzer (COSTEP)
The COSTEP instrument detects and classifies very energetic particle populations of solar, interplanetary, and galactic origin. It is a complementary instrument to ERNE (for more information, see below).
Principal Investigator: B. Heber, University of Kiel, Germany

Extreme ultraviolet Imaging Telescope (EIT)
EIT provides full disc images of the Sun at four selected colours in the extreme ultraviolet, mapping the plasma in the low corona and transition region at temperatures between 80 000 and 2 500 000°C.
Principal Investigator: F. Auchère, Institut d'Astrophysique Spatiale, Orsay, France

Energetic and Relativistic Nuclei and Electron experiment (ERNE)
ERNE measures high-energy particles originating from the Sun and the Milky Way. It is a complementary instrument to COSTEP.
Principal Investigator: E. Valtonen, University of Turku, Finland

Global Oscillations at Low Frequencies (GOLF)
GOLF studies the internal structure of the Sun by measuring velocity oscillations over the entire solar disc.
Principal Investigator: P. Boumier, Institut d'Astrophysique Spatiale, Orsay, France

Large Angle and Spectrometric Coronograph (LASCO)
LASCO observes the outer solar atmosphere (corona) from near the solar limb to a distance of 21 million kilometres, that is, about one seventh of the distance between the Sun and the Earth. LASCO blocks direct light from the surface of the Sun with an occulter, creating an artificial eclipse, 24 hours a day, 7 days a week. LASCO has also become SOHO's principal comet finder.
Principal Investigator: R. Howard, Naval Research Laboratory, Washington DC, USA

Michelson Doppler Imager/Solar Oscillations Investigation (MDI/SOI)
MDI records the vertical motion ("tides") of the Sun's surface at a million different points for each minute. By measuring the acoustic waves inside the Sun as they perturb the photosphere, scientists can study the structure and dynamics of the Sun's interior. MDI also measures the longitudinal component of the Sun's magnetic field.
Principal Investigator: P. H. Scherrer, Stanford University, California, USA

Solar Ultraviolet Measurements of Emitted Radiation (SUMER)
The SUMER instrument is used to perform detailed spectroscopic plasma diagnostics (flows, temperature, density, and dynamics) of the solar atmosphere, from the chromosphere through the transition region to the inner corona, over a temperature range from 10 000 to 2 000 000°C and above.
Principal Investigator: W. Curdt, Max-Planck-Institut für Sonnensystemforschung, Katlenburg-Lindau, Germany

Solar Wind Anisotropies (SWAN)
SWAN is the only remote sensing instrument on SOHO that does not look at the Sun. It watches the rest of the sky, measuring hydrogen that is 'blowing' into the Solar System from interstellar space. By studying the interaction between the solar wind and this hydrogen gas, SWAN determines how the solar wind is distributed. As such, it can be qualified as SOHO's solar wind 'mapper'.
Principal Investigator: E. Quémerais, Service d'Aéronomie du CNRS, Verriéres-Le-Buisson, France

UltraViolet Coronograph Spectrometer (UVCS)
UVCS makes measurements in ultraviolet light of the solar corona (between about 1.3 and 12 solar radii from the centre) by creating an artificial solar eclipse. It blocks the bright light from the solar disc and allows observation of the less intense emission from the extended corona. UVCS provides valuable information about the microscopic and macroscopic behaviour of the highly ionised coronal plasma.
Principal Investigator: J. L. Kohl, Smithsonian Astrophysical Observatory, Cambridge, Massachusetts, United States.

Variability of Solar Irradiance and Gravity Oscillations (VIRGO)
VIRGO characterises solar intensity oscillations and measures the total solar irradiance (known as the 'solar constant') to quantify its variability over periods of days to the duration of the mission.
Principal Investigator: C. Fröhlich, Physikalisch-Meteorologisches Observatorium Davos, Switzerland

Operations

Ground control and Science Operations

SOHO is operated from NASA's Goddard Space Flight Center (GSFC) near Washington. There an integrated team of scientists and engineers from NASA, partner industries, research laboratories and universities works under the overall responsibility of ESA. Ground control is provided via NASA's Deep Space Network antennae, located at Goldstone (California), Canberra (Australia), and Madrid (Spain).

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