Solar Orbiter

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E. Marsch
Solar Orbiter

Background

- The Solar Orbiter (SO) developed from InterHelios
- SO has been selected as a candidate for an F2/F3 ESA mission!
- Additional mission scenarios, including polar orbits and closer approaches to the Sun, were discarded
- Because of technology developments required (SEP), ESA conducted an assessment study
- Estimated cost 232 M Euro (budget overrun of 30%)
- It is required that SO is made an international effort involving NASA or other national agencies
New frontiers in solar physics

The different parts of the Sun and its environment from the interior to the heliosphere are coupled through the magnetic field

- Magnetoconvection below the photosphere and flux emergence
- Distribution and evolution of photospheric magnetic field
- Morphology and dynamics of magnetic network and coronal field
- Coronal expansion, solar wind and heliospheric magnetic field
- Interplanetary manifestations of solar magnetic activity
Solar physics after SOHO: New goals

- Unravel couplings between all layers of the solar atmosphere
  ----> make multi-wavelength simultaneous observations at very high spatial resolution!

- Disentangle spatial and temporal variations in the solar wind
  ----> choose orbit enabling S/C corotation with the Sun!

- Uncover missing links for understanding the solar dynamo
  ----> observe the Sun from high latitudes!
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Novel measurements

- Observe all layers of the solar atmosphere at high spatial resolution (37 km) from near the Sun (45 Rs)

- Separate spatial and temporal variations in the solar wind from quasi-corotational orbit (1.3° per day)

- Enable first observations of the polar regions of the Sun from out-of-ecliptic vantage points (up to 38° in heliographic latitude)
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Origin of fast solar wind in magnetic network of the polar coronal hole
Coronal mass ejection as seen by SOHO
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Coverage of solar and heliospheric physics

- **Interior**
  - **Dynamo** -> image solar poles and determine magnetic field

- **Photosphere and Chromosphere**
  - **Luminosity** -> measure irradiance changes (at high latitudes)
  - **Flux tubes** -> resolve small-scale magnetic elements (<100 km)

- **Corona**
  - **Loops** -> image and take spectra of prominences and CMEs
  - **Flares** -> measure neutrons, radio emissions and particles

- **Heliosphere**
  - **Streams** -> separate structures from turbulence and waves
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Programmatics

- Mission managed and financed mainly by ESA, but with strong international collaboration
- PI-type mission, instruments supplied by community
- Maximum use of available technology, off-the-shelf (in 2004) or from the Mercury Orbiter Cornerstone
- Launcher: Soyuz-Fregat from Baikonur (RSA)
- S/C and science operations performed with a single ground station
- Design lifetime compatible with a 7-year mission
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Scientific payload: Solar instruments

- Visible-light imager and magnetograph
- EUV imager and spectrometer
- X-ray / EUV imager
- Ultraviolet and visible light coronagraph
- Neutron and $\gamma$-ray detector
- Radiometer
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Scientific payload: Heliospheric instruments

- Solar wind plasma analyser
- Plasma wave analyser
- Magnetometer
- Energetic particle detector
- Neutral particle detector
- Dust detector
- Radio spectrometer
- Coronal radio sounding
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**Mission characteristics**

- **Orbit**: variable inclination (heliographic), $0 \geq i \geq 38^\circ$; perihelion down to 45 Rs
- **S/C platform**: 3-axis stabilised, Sun-pointing, stability 1 arcsec/15 min (pointing error <2 arcmin)
- **Launch date**: January 2009, compatible with F2/F3
- **Lifetime**: cruise: $\approx$ 2 years, scientific observations: nominal $\approx$ 3 years and extended $\approx$ 2 years
- **Payload**: solar-remote package + in-situ package
- **Mass**: payload $\approx$ 137 kg, S/C $\approx$ 1500 kg
- **Data rate**: 70 kb/s for instruments
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Trajectory, projected on the ecliptic plane
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S/C perihelion radius versus flight time
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S/C solar heliographic latitude versus flight time
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Modes of operation during the mission

- **Time Share Observation Mode**
  - No data from:
    - EUV/X-Ray Imager
    - EUV Spectrometer/Imager
    - Magnetograph
    - Coronograph

- **Nominal Observation Mode**
  - Maximum Northern Latitude: +/- 5 days

- **Time Share Observation Mode**

- **Nominal Observation Mode**
  - Perihelion: +/- 5 days

- **High Rate Downlink**
  - Communication above 0.6 AU

- **Nominal Observation Mode**
  - Maximum Southern Latitude: +/- 5 days

0.6 AU
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Downlink capabilities during mission

![Graph showing downlink capabilities during mission periods.](image)
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**Conclusions: Solar Orbiter will...**

- explore **unknown territory** near the Sun
- provide unprecedented **high-resolution observations** of the Sun (> 37 km)
- deliver for the first time images of the **solar poles**
- correlate in-situ with remote-sensing measurements at 45 Rs from a **quasi-corotational** vantage point
- **ideally complement the LWS program!**
- open new ground in solar and heliospheric physics!