HELIOSEISMOLOGY FROM SPACE, THE SOHO PROJECT

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1. Introduction

As a cornerstone of its long term plan for space science research, the European Space Agency (ESA) is developing the Solar Terrestrial Physics Programme that consists of two parts: one, the Solar and Heliospheric Observatory (SOHO) for the study of the solar internal structure and the physics of the solar corona and the solar wind, and another, CLUSTER, a series of four spacecraft flying in formation to study small scale plasma phenomena in several regions of the magnetosphere and in the near Earth solar wind. The feasibility of the missions was demonstrated in Phase A studies carried out by industrial consortia under the supervision of ESA (1,2). According to the current plans an announcement of opportunity calling for instrument proposals will be issued by ESA during the first quarter of 1987. It is foreseen that the spacecraft will be launched by the end of 1994.

2. SOHO aims and model payload

The Solar and Heliospheric Observatory (fig.1) has been proposed with the following aims:

- To investigate and understand the physical processes that form the solar corona, maintain it and give rise to the expanding solar wind, by high resoltuion spectroscopy of the chromosphere, transition region and corona. In combination with,
- 'in situ' study of the resulting solar wind streams and associated fields.
- To investigate the solar interior structure by methods of helioseismology.

Table 1 summarises the resources allocated to the instruments of the model payload that has been proposed for SOHO to fulfil its aims.

The helioseismology part of the model payload consists of three instruments, that have been chosen with the aim that they provide those measurements that are either impossible or very difficult to

J. Christensen-Dalsgaard and S. Frandsen (eds.), Advances in Helio- and Asteroseismology, 545–548.

obtain from ground-based observatories, because of the earth atmosphere effects or because of the earth rotation:

A high resolution spectrometer (HRS) to measure globar solar velocity oscillations with a sensitivity significantly below the intrinsic solar velocity noise power. This instrument's main aim will be the study of long period, low degree modes.

A solar irradiance monitor (SIM) to measure globar solar luminosity oscillations with a precision of 10^{-6}, at several wavelengths. It will complement the measurements of HRS, and provide spectral information on the solar constant variations.

A solar oscillations imager (SOI), which delivers two-dimensional images of the velocity of the solar surface with a spatial resolution of 2x2 $arcsec^2$, to study oscillation modes of degrees up to 600.

3. SOHO Spacecraft and Operation, characteristics that are relevant for helioseismologic observations.

SOHO will be a three-axis stabilised spacecraft with one axis permanently pointed to the Sun center within 10 arcsec. It will have a pointing stability better than 1 arcsec/15 min. and a roll stability around the same axis of 1.5 arcmin./15 min.

SOHO will be located into a halo orbit (period ≅ 180 days) around the Earth-Sun L1 Lagrangian point at 1.5 x 10^6 km from the Earth. Therefore, it will be permanently in sunshine, a major feature of SOHO for the measurement of solar oscillations.

The mission will have a minimum lifetime of 2 years and will carry consumables for a life of at least 6 years.

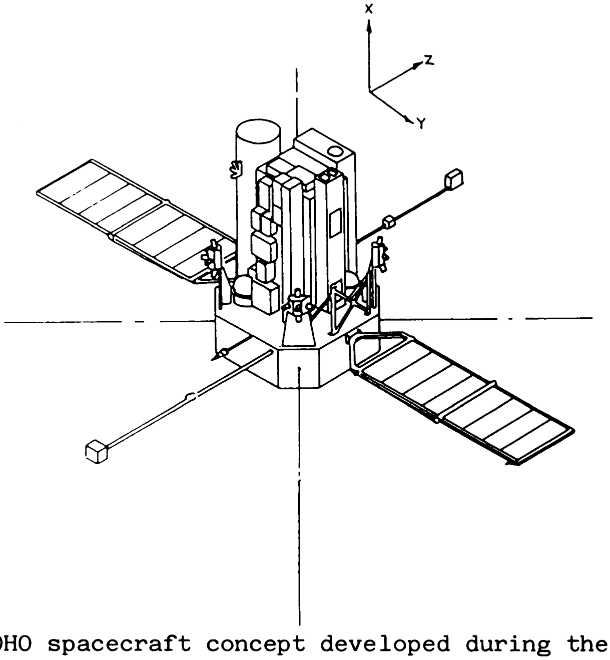

Figure 1. SOHO spacecraft concept developed during the Phase-A Study.

https://doi.org/10.1017/S007418090015867X Published online by Cambridge University Press

Table 1 : SOHO MODEL PAYLOAD

EXPERIMENTS	MASS kg	POWER w	TELEMETRY kb/s
Coronal Physics			
Grazing incidence spectrometer (GIS)	120	57	12
Normal incidence spectrometer (NIS)	130	44	10
EUV imaging telescopes (EIT)	16	30	0.8
UV coronal spectrometer (UVCS)	165	36	5
White-Light coronagraph (WLC)	64	46	4.2
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	495	213	32
Solar wind 'in situ'			
Solar wind plasma analyser (SWP)	8	8	0.6
Solar wind composition analyser (SWC)	13	13	0.8
Suprathermal particle analyser (STP)	8	7	0.5
Energetic particle analyser (EPA)	14	12	0.7
Magnetomer (MAG)	2	3	0.2
Plasma wave analyser (PWA)	7	7	0.4
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	52	50	3.2
Helioseismology			
High resolution spectrometer (HRS)	38	22	0.1
Solar oscillations imager (SOI)	53	59	5 (160)
Solar irradiance monitor (SIM)	16	15	0.1
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	107	96	5.2
TOTAL	654	359	49.4(200)

The Sun-spacecraft velocity changes due to orbital motion are smooth and the changes due to spacecraft station keeping will be measured. A simulation of the spacecraft operations and velocity measurements shows (fig.3) that the power spectrum of the velocity determination error lies well below the expected instrument and solar noise values.

On the telemetry, special provisions will be taken to ensure a continuous coverage during at least 2 years of 200 b/s obtained by the full disk helioseismology instruments. For the solar oscillation images 160 kb/s will be transmitted uninterrupted during at least 2 consecutive months per year, 160 kb/s during at least 8 hours/day, 5 kb/s during at least 18.5 hours/day.

4. Concluding remarks

SOHO will provide the necessary resources and capability for space born instruments that will considerably improve upon the data obtained

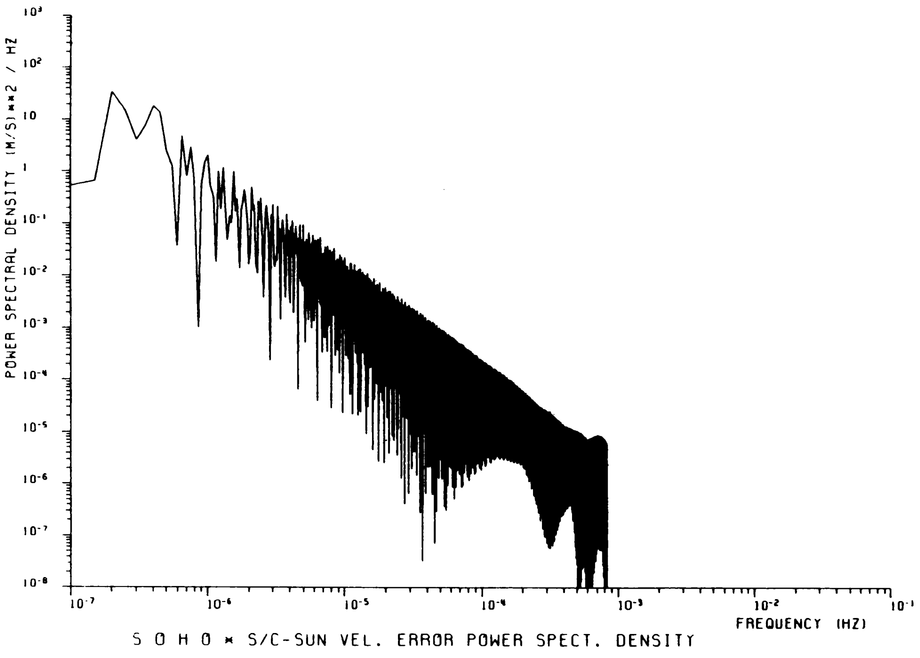

Figure 2. Residual power spectral density of spacecraft-Sun velocity calculated with the simulated SOHO maintenance in L1 halo orbit using a cold gas system.

from the ground based helioseismology observations, particularly for high degree modes, and may obtain crucial data for long period, low degree modes.

It is important to notice that the actual payload will depend on the result of the experiments selection, and that some of the resources and spacecraft characteristics will be negotiated for a most efficient use of the available financial resources.

References

1. **SOHO, Solar and Heliospheric Observatory, ESA Report on the Phase-A Study**, SCI (85)7, by the Directorate of Scientific Programmes. (Noordwijk, December 1985).

2. **CLUSTER, Study in Three Dimensions of Plasma Turbulence and Small-Scale Structure, ESA Report on the Phase-A Study**, SCI (85)8, by the Directorate of Scientific Programmes. (Noordwijk, December 1985).

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