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SPACE SOLAR TELESCOPE

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ABSTRACT

Space Solar Telescope (SST) is a space project for solar research, its main parameters are that total weight 2.0T, sun synchronous polar circular orbit, altitude of the orbit 730KM, 3 axis stabilized attitude system, power 1200W, telemetry of the downlink rate 30Mb/s, size 5*2*2 M^3, mission life 3 years. It is expected it will be launched in 2001 or later. The main objective is structure and evolution of solar vector magnetic field with very high spatial resolution. The payloads are consisted of 6 instruments: Main optical telescope with 1-M diameter and diffraction limited resolution 0.1 arc second, EUV imaging telescope with a bundle of four telescopes and 0.5 arc second resolution, spectrometric optical coronagraph, wide band spectrometer, H-*alpha* and white light telescope and solar and interplanetary radiospectrometer. An assessment study between China and Germany is under operation.

Key Words : Solar physics, Space Astronomy

I. INTRODUCTION

Yohkoh has been in operation for about 5 years (Ogawara, Y. et al., 1991), SOHO has been launched and running successfully (Fleck, B., Domingo, V. and Poland, A., 1995). The two solar spacecrafts have made great contribution for solar physics and interplanetary research. Which is the next? In my opinion, the structure and evolution of solar vector magnetic field with very high spatial resolution in the photosphere and chromosphere and corona will be main target. This is because: 1) solar magnetic field pay a very impatient role in solar activity, solar atmosphere, and interplanetary disturbances. 2) The small spatial scale of magnetically constrained structures and processes in solar atmosphere require very high spatial resolution observations in visible, which is about 0.1 arcsecond. The limited resolution from the earth atmosphere disturbances hinders a lot of very important phenomena to be observed. A space solar telescope has been proposed, since 1992 (Ai, 1995). The main scientific objective are to achieve a break through advance in solar physics through coordinated, wide waveband coverage, high resolution observation of transient and steady state solar hydrodynamic and magnetohydrodynamic processes. The key is observations of vector magnetic field with 0.1 arcsecond resolution and soft-X image with 0.5 arcsecond.

At present, an assessment study of SST cooperation between Chinese Academy of Sciences and Max-Planck Association of Germany is under operation. The principle institute is Max-Planck-Institut of aeromony and principle investigator is Dr. W. K. Schmidt (Germany) as well as Beijing Astronomical Observatory and myself (China). A middle experiment about balloon-born solar telescope with 80cm diameter and partial of design of SST is running in Chinese side.

II. PAYLOADS

The SST payloads are consisted of 6 instruments.

1) Main Optical Telescope (MOT), the schema of MOT is shown in Fig.1. Its objective (M) is paraboloidal mirror with 1M effective diameter, focal rate is 3.5:1, the field of view is about 1.7'*1.3', the solar light outside the field of view is reflected by the stop, the rest heat is transported to outside by heatpipe. LC is the collimator consisted of lens, the angular magnification is 22.5, I is the wide band filter ($\leq \lambda$ 6600), then the polarimeter is consisted of quieter wave plate (λ /4), polaroid (P_1) and half wave plate (λ /2), the polarimeter fits with the birefringent filter very well and can get accuracy 10^{-4} of measure polarization, the stoke parameters (I, Q, U, V) will be measure according the model listed in table 1.

Then the stokes parameters are obtained as following:

$$I = \frac{1}{2}(S_{V1} + S_{V2}) \text{ or } \frac{1}{2}(S_{Q1} + S_{Q2});\ \frac{1}{2}(S_{U1} + S_{U2})$$

$$V = \frac{S_{V1} - S_{V2}}{S_{V1} + S_{V2}}$$

$$Q = \frac{S_{Q1} - S_{Q2}}{S_{Q1} + S_{Q2}}$$

$$U = \frac{S_{U1} - S_{U2}}{S_{U1} + S_{U2}}$$

When phase error of the λ /4 is $\pm$ 0.10^O or less, the degree of polarization of P_1 and P_2 are 0.9998 and 0.998 separately, error of orientation of P_1 is $\pm$ 10" or less, the errors of oriantation of P_2 and λ /2 are $\pm 0.01^O$ or less, phase error of the λ /2 is $\pm 1^O$ or less, the accuracy 2×10^{-4} of measure stokes parameters will be obtained. The correlation tracker is consisted of the tip-tilt mirror, associated optical system, CCD camera with 64*64 pixels and control system. The equivalent focal length of optical system of the correlation tracker

Table 1.

measured polarization component	angle of elements $\lambda/4$	P_1	$\lambda/2$	P_2 polaroid of the filter
$S_{V1}(I+V)$	0^{deg}, in	$+45^{deg}$	$+22.5^{deg}$	0^{deg}
$S_{V2}(I-V)$	0^{deg}, in	-45^{deg}	-22.5^{deg}	0^{deg}
$S_{Q1}(I+Q)$	out	0^{deg}	0^{deg}	0^{deg}
$S_{Q2}(I-Q)$	out	$+90^{deg}$	$+45^{deg}$	0^{deg}
$S_{U1}(I+U)$	out	$+45^{deg}$	$+22.5^{deg}$	0^{deg}
$S_{U2}(I-U)$	out	-45^{deg}	-22.5^{deg}	0^{deg}

Table 2.

wavelength	Log T	wave range	focal length	FoV	angular resolution
HeII 303.91 Å	0.05 MK	6 Å	100 cm	85'*85'	2.5"/pixel
FeXV 284.15 Å	2.0 MK	5 Å	400 cm	8.5'*8.5'	0.25"/pixel
FeXII 180.41 Å	1.3 MK	6 Å	400 cm	8.5'*8.5'	0.25"/pixel
FeXXII 128.73 Å	10 MK	2 Å	400 cm	8.5'*8.5'	0.25"/pixel

Table 3. Basic Instrument Information

Topic	MOT	WBS	HAT	EUV	SOC	SIRA
Mass	800 kg	30 kg	50 kg	131 ± 15 kg	35 ± 7 kg	8 kg
Size (cm)	450*Φ120 +250*80*30	30*40*15	200* Φ 20	300* Φ 50	145*25*35	100 cm dipoles
Power	600 W	20W	40W	30 W (28 V DC)	35 W ± 20%	49 W
Data rate	5MB/s, max 23GB/day, max	1KB/s, max 25MB/day, max	1MB/s, max 2GB/day, max	6MB/s, max 6GB/day max	5GB/s 2GB/day	1.3GB /day

The Items 1, 4, 5 are provided by Chinese side.
The Items 2, 3, 6 are provided by Germany side.

is 20M, the size of pixels of CCD is 15 μ m, 64*64 pixels are binned to 32*32 pixels, then each pixel corresponds 0.3094" on the sun, the field of view of the CCD is about 9.9". The systematic accuracy is about ± 0.02", the response frequency is about 100Hz. Then the imaging lens LI makes the beam as telecentric optical system in which the beams distribution at the filter plane is identical for all image point and therefore neither the filter profile nor control wavelength changes over the focal plane. The LI makes the system has an equivalent focal length, F_3=44.43M, which corresponds 0.065"/pixel, when size of pixel is 14 μ m. When the Mirror M_3 is out, the beam enter the 2-D spectrograph. The stokes parameter profile will be observed. When M3 is in, the white-light beam is fold to a CCD system. The CCD system has very short exposure time, 10^{-4} second, which can freeze the motion of the image introduced by trouble of satellite attitude controller or correlation tracker, then image of high spatial resolution can be obtained, the size of the CCD's pixel corresponds 0.05" on the sun, in about 4000 $\AA$, so 0.1" resolution can be obtained. The filter wheel W_1 and W_2 are also consisted of two single wheels. Each wheel has 6 holes, 5 of them are interference filters, rest one is empty, so 10 interference filters will can be used. 2-D spectrograph (2DS) with 16-channel will be used in MOT. The system of 2DS have 0.05 $\AA$ spectral resolution ($\lambda 5324 \AA$), this is a tunable system, working wave length is from 3800 $\AA$ to 6600 $\AA$.

2) EUV Imaging Telescope (EUT) It is a bundle of four normal incidence telescopes with multilayer coatings primary mirrors, the diameter of each telescope is 12cm. 4 CCDs with 2048*2048 pixels are as detectors. The parameters of the 4 telescopes are shown in table 2.

3) Spectrometric Optical Coronagraph (SOC) The

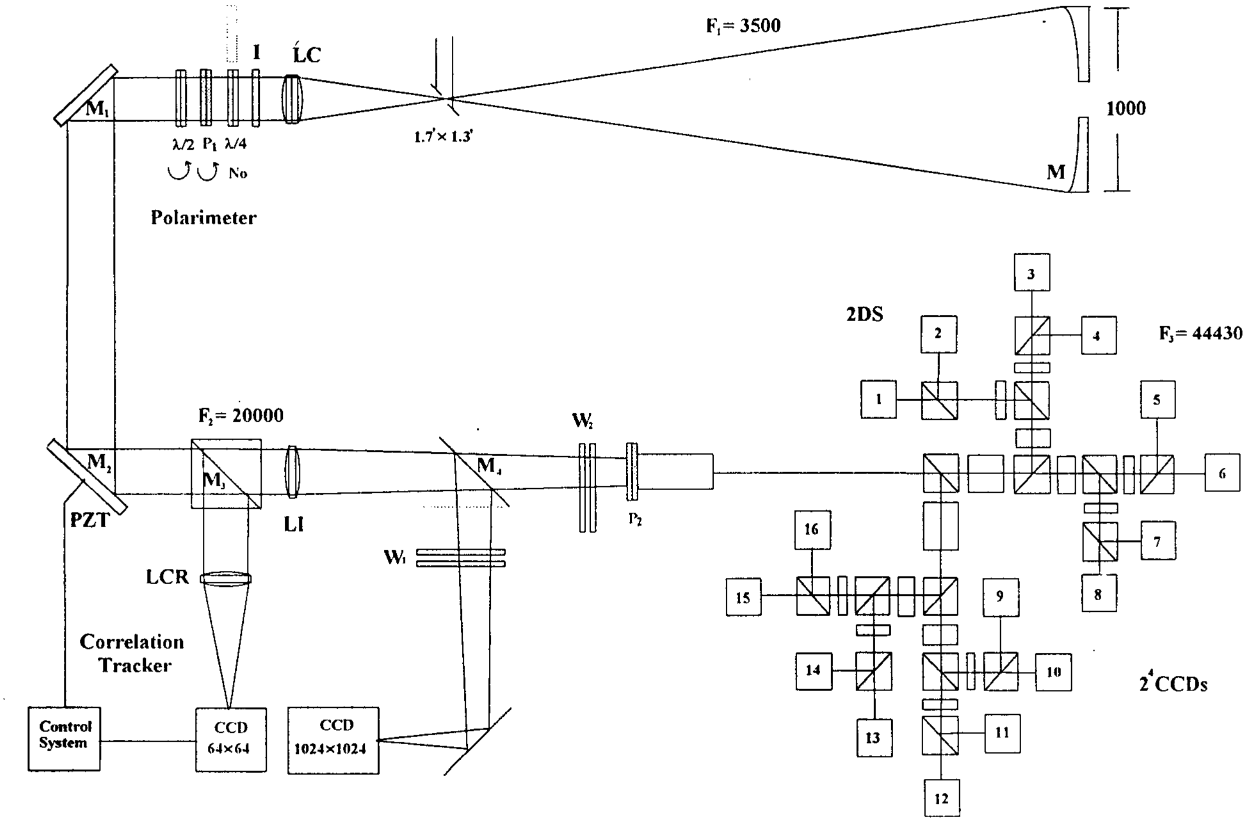

Fig. 1.— Scheme of the Main Optical Telescope

system is as same as the C_1 coronagraph in SOHO (Brueckner et al., 1995), which is mirror Lyot coronagraph with 4.7 cm entrance aperture. The narrorbandpass tunable Febry-Perot interferometer, and 1024 *1024 CCD Camera are used.

4) Wide Band Spectrometer (WBS) It is consisted of three bands: 1) soft X-ray, 2-30 kev, 64 channels; 2) hard X-ray, 15-450 kev, 64 channels; 3) Gamma-ray, 0.3-14 Mev, 128 channels.

5) H-alpha and white light telescope (HAT) This is a cassegrain telescope with 12 cm primary mirror. After the collimator the light is split by a polarizing beam splitter as two beams. One beam passes the H_α filter with 0.5 $\AA$ passband, then form a H_α image in CCD with 2048*2048, other beam form a white light image in other CCD with 2048*2048, which is used for observation of white-light flare and the photospheric background with 1"/pixel.

6) Solar and Interplanetary Radiospectrometer (SIRA) The dimensions of the dipoles is about 1M. the frequency range is 100KHz-60MHz. The flux density and the degree of circular polarization will be measured. The basic parameters of the six instruments are shown in table 3.

III. SATELLITE

The total weight of the Satellite is about 2.0T. The size is 5*2*2M^3. The total power is 1200W in average, 14 M^2 solar cell panel. The sun synchronous polar circular orbit will be used. The altitude is 730KM, the 3 axis stabilized attitude control will be used. The telescope points always to the solar disc. The pointing accuracy is ± 12" (solar disc) and ± 40" (the ecliptic pole), attitude control stability is ± 3"/s (solar disc) and no constraint (ecliptic pole). The Data recorder is about 6GB/day, compressed by 5 times. The Data storage is 4GB. The telemetry parameters are that down link rate is 30Mb/s, X waveband (8200MHz), the up link rate 4kb/s, 1700 MHz. The system will be launched by LM-4B rocket. It is expected the Launch time is 2001 or later, the next solar activity maximum.

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