Some Schemes of Space Solar Telescope

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1. Introduction

The Space Solar Telescope (SST) (Ai, 1993), similar to the Japanese Solar-B (Hirayama, 1993), has been proposal. In this paper, some schemes of the main optical telescope will be discussed. In my opinion the telescope should have the following functions:

(1) about 0.1" diffractive limiting spactial resolution in visible spectrum;
(2) additional polarization from the telescope should be as small as possible;
(3) stokes parameter profile of line with 2-Dimensional real time field of view;
(4) ability in ultra violet and near infrared.

According to the above functions, two Schemes of the main optical constructure, and some of the multichannel filters will be discussed.

2. Scheme I: Gregorian system add two total reflect prims

The Scheme is shown in Figure 1. The scheme has four characteristic points:
(1) two total reflect prisms, made out of BAK4 or TF2 are instead of the two reflect plates in OSL (Hartmann, 1991), the two prisms serve two functions: (A) they fold the beam to decrease the length of tube; (B) they act as an achromatic quarter wave plate. But in OSL, the additional polarization from two reflect plates is not definite and changes probably as time goes on. The retardation from the prism are shown in Table 1.

(2) The total transmitting birefringent filter (Ai and Hu, 1987) can be used, which has double the transmissivity than the traditional Lyot filter. When the bandwidth is 1/8 Å, the transmissivity is as high as 25%-30%, this is special advantage for decreasing the diameter of the telescope, increasing the spatial resolution and shorting the exposure time.

(3) The KD*P electrical-optical modulator is set in collimatic beam. The error of

retardation from field of view in the three type of KD^*P modulators are shown in Table 2. KD^*P modulator with narrow field of view is consisted of two conduct grasses sandwich a piece of KD^*P with $\pm \lambda/4$. The type I with wide field of view of KD^*P modulator is consisted of two group KD^*P modulators with $\pm \lambda/8$ in which opposite vantage are put and sandwich a $\lambda/2$ wave plate. The type II with wide field of view of KD^*P modulator are consisted of 4 group KD^*P, the first group and lost group are same, but with opposite voltage of $\pm \lambda/4$, the second and third one are same, but also with opposite voltage of $\pm \lambda/8$ and sandwich $\lambda/2$ wave plate. As an example, $d_1=d_4=2.08$, $d_2=d_3=1.50$mm, the results of field of view are shown in table 2.

If the relative error of ± 5% is permit, the largest field of view are separately 1.2°, 2.0° and 3.8° for Narrow, type I and type II of KD^*P modulators.

The type I is selected and is used in collimetric beam. When field of view is 2'×2', the angular magnifying power of the collimation lens is 45, the incident angle coming into the KD^*P is about 2°, so the type I of KD^*P can be used here.

(4) A tilt correlation tracker will be used to improving of the pointing accuracy of the telescope. A low spatial and temporal resolution Hartmann-shack type wavefront sensor will be used to sense and update the mirror alignment and wavefront error of optical ayatem.

3. Scheme II: Primary mirror add secondary lens.

The Scheme II is shown in Figure 2. The characteristic points are followings:
(1) The central obscuration decrease from 1/4 of diameter of primary mirror to smaller than 1/10, that will improve the Modulation Transfer Function of the system, then will permit larger the wavefront errors of the system.

(2) The heat rejection mirror in focus of the primary mirror can be set vertically to the optical axis, then the stop of field of view will have sharp limb, so the scattered light will be decreased.

(3) The polarizing analyser including KD^*P modulator and achromatic wave plates will be placed after the secondary lens, so the beam with small angle of field of view will pass the system.

(4) Similar to the Scheme I, the tilt correlation tracker and wavefront corrector can be set.

(5)The total transmitting filter can be used also for the system.

(6) The achromatism of the lens is not as good as the secondary mirror. It is necessary to design the lens in detail.

4. Filter

Three type of birefringent filters are proposed.

(1) A total transmitting universal filter with 1/7 Å in 5324 Å or 5250 Å. The transmissivity is about 0.25-0.30, which has double transmissivity than one of the traditional Lyot filter, it is special advantage that the diameter of the telescope decrease to 1/ 2, the focus and luminosity keep same. The size is 350^{mm} (length) $\times 120^{mm}$ (wide) $\times$ 80 (high).

(2) A two dimensional real time spectrograph with 8-channel, (Ai, 1991) and bandwidth is 1/8 Å in H_α is used to obtain the Stokes parameters of the spectral line, then vector magnetic field, velocity field and other physical field can observed simultaneously.

(3) A birefringent filter in λ 8600 Å of line P15 for an electrograph.

Now, a balloon telescope with 2/3 size, 67 cm diameter, is under developing for middle-stage experiment of the space of solar telescope.

Reference

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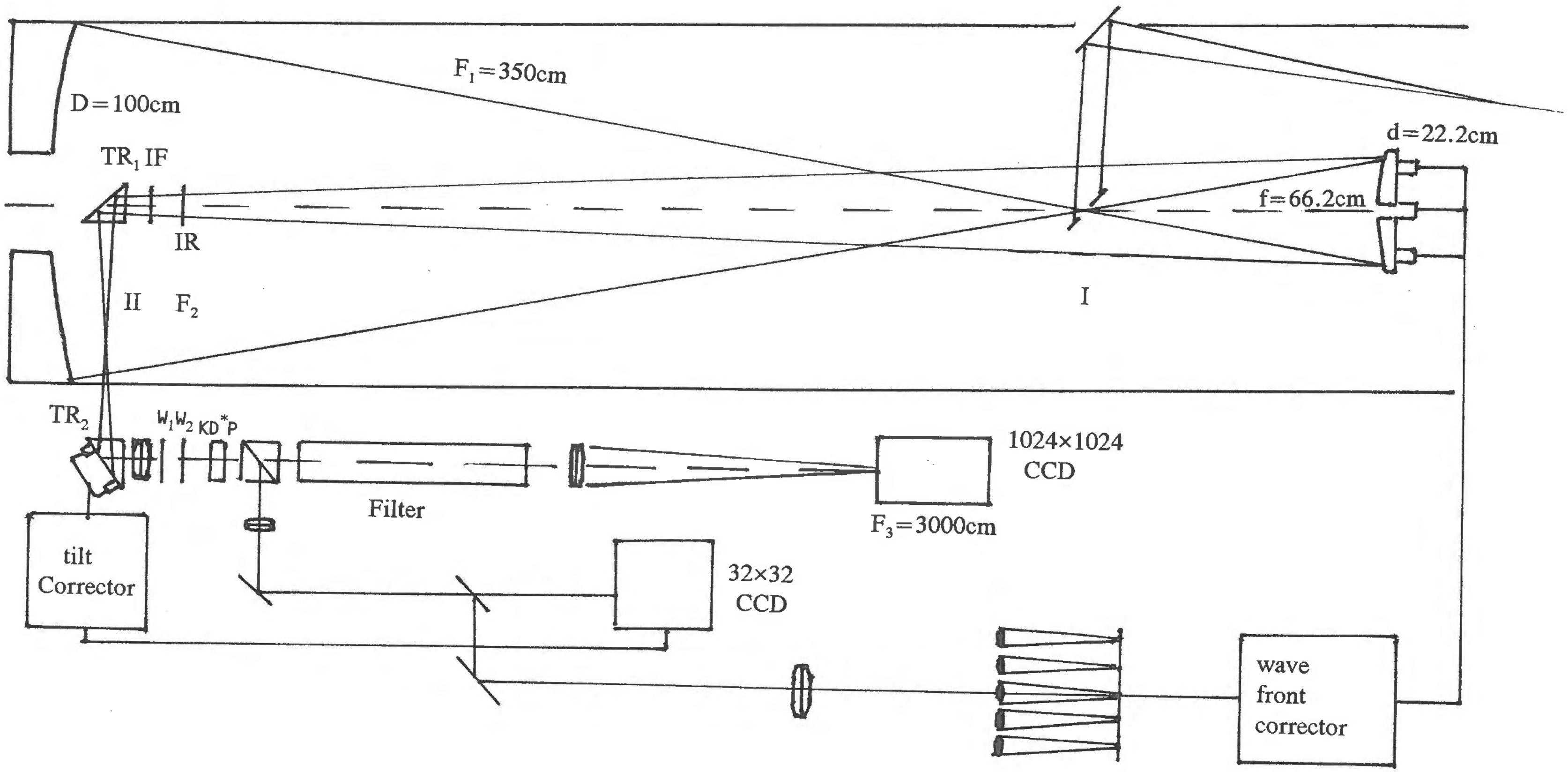

Fig.1 Scheme of Space Solar Telescope with Gergorian and two Totally Reflect Prizms

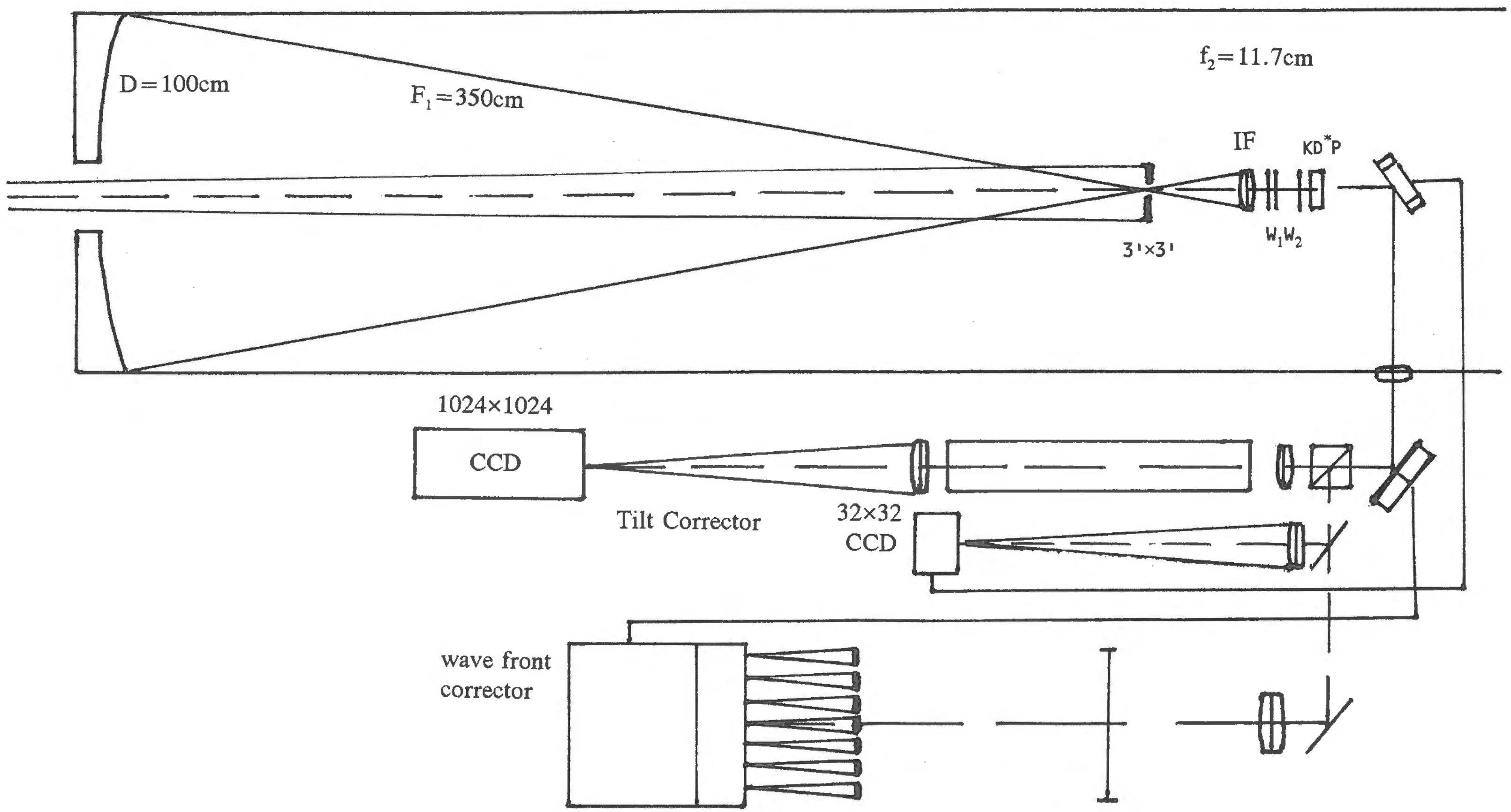

Fig.2 Scheme of Space Solar Telescope with a Secondary lens System

Table Ⅰ. Phase difference of the total reflect prism

A・ BAK—4

n	1.57364	1.56787	1.56321	1.55853	1.55456	1.55248	1.55240	1.54981	1.54674
	3650.1	4046.6	4358.4	4861.3	5460.7	5876.5	5892.9	6562.7	7665.0
45°	94.72	93.22	92.32	91.18	90.20	89.68	89.66	88.98	88.20
46°	48.70	48.05	47.66	47.17	46.75	46.53	46.52	46.23	45.89
44°	45.40	44.50	43.96	43.29	42.70	42.38	42.37	41.97	41.49
46°+44°	94.10	92.55	91.62	90.46	89.45	88.91	88.89	88.20	87.38
46.5°	49.18	48.57	48.20	47.75	47.36	47.15	47.14	46.88	46.56
43.5°	44.10	43.12	42.52	41.76	41.12	40.77	40.76	40.31	39.78
46.5°+43.5°	93.28	91.69	90.72	89.53	88.48	87.92	87.90	87.19	86.34

B・ TF2

n	1.58304	1.57363	1.56825	1.56188	1.55661	1.55398	1.55380	1.55048	1.54667
	3650.1	4046.6	4358.4	4861.3	5460.7	5876.5	5892.9	6562.7	7665.0
45°	96.78	94.72	93.50	92.00	90.70	90.04	90.00	89.16	88.18
46°	49.59	48.70	48.17	47.52	46.97	46.68	46.67	46.31	45.89
44°	46.61	45.40	44.67	43.77	43.01	42.60	42.58	42.08	41.48
46°+44°	96.20	94.10	92.84	91.29	89.98	89.28	89.25	88.37	87.37
46.5°	50.01	49.18	48.68	48.08	47.56	47.29	47.28	46.95	46.56
43.5°	45.43	44.10	43.30	42.31	41.46	41.01	40.99	40.43	39.76
46.5°+43.5°	95.44	93.28	91.98	90.39	89.02	88.30	88.27	87.38	86.32

Table Ⅱ. Errors of KD*P from field of view ($\lambda = 5324A$, $\pm \lambda / 4$)

Type	θ	0°	10°	20°	30°	40°	45°	50°	60°	70°	80°	90°
narrow field	0.5°	0.23876	0.23948	0.24155	0.24468	0.24847	0.25046	0.25244	0.25612	0.25907	0.26098	0.26164
d=2mm	0.6°	0.23372	0.23478	0.23781	0.24238	0.24787	0.25074	0.25358	0.25883	0.26303	0.26574	0.26667
Ⅰ	0.9°	0.25009	0.25148	0.25483	0.25837	0.26056	0.26085	0.26056	0.25837	0.25483	0.25148	0.25009
d=2mm	1.0°	0.25007	0.25228	0.25744	0.26271	0.26587	0.26629	0.26587	0.26271	0.25744	0.25228	0.25007
Ⅱ type with	0.1°	0.25027	0.25027	0.25027	0.25027	0.25027	0.25027	0.25027	0.25027	0.25027	0.25027	0.25027
	0.3°	0.25026	0.25026	0.25026	0.25026	0.25026	0.25026	0.25026	0.25026	0.25026	0.25026	0.25026
$d_1 =$ 2.08mm	0.5°	0.25025	0.25025	0.25024	0.25024	0.25023	0.25023	0.25023	0.25024	0.25024	0.25025	0.25025
add $\pm \lambda/4$	0.7°	0.25024	0.25023	0.25020	0.25018	0.25016	0.25016	0.25016	0.25018	0.25020	0.25023	0.25024
	0.9°	0.25024	0.25019	0.25010	0.25005	0.25004	0.25004	0.25004	0.25005	0.25010	0.25019	0.25024
$d_2 \fallingdotseq$ 1.50mm	1.1°	0.25021	0.25006	0.24983	0.24979	0.24985	0.24987	0.24985	0.24979	0.24983	0.25006	0.25021
add $\pm \lambda/8$	1.3°	0.25020	0.24968	0.24816	0.24936	0.24976	0.24982	0.24976	0.24936	0.24816	0.24968	0.25020
	1.5°	0.25018	0.24847	0.24760	0.24880	0.25005	0.25024	0.25005	0.24880	0.24760	0.24847	0.25018
	1.7°	0.25016	0.24457	0.24458	0.24842	0.25127	0.25166	0.25127	0.24842	0.24458	0.24457	0.25016
	1.9°	0.24968	0.23367	0.24026	0.24899	0.25412	0.25479	0.25412	0.24899	0.24026	0.23367	0.24968
	2.1°	0.19743	0.21537	0.23662	0.25164	0.25933	0.260296	0.25933	0.25164	0.23662	0.21537	0.19743