Ground-based Solar Observations in the Space Instrumentation Era
ASP Conference Series, Vol. 504
Ivan Dorotovič, Catherine E. Fischer, and Manuela Temmer, eds.

The Chinese Giant Solar Telescope

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Abstract. Chinese solar community has proposed a next generation ground-based solar telescope , The Chinese Giant Solar Telescope (CGST). CGST is an infrared and optical telescope whose basic objective is to resolve fundamental magnetic structure of Sun at the level of ~20 km in the wavelength of 1 micron. The preliminary design of CGST includes an 8-meter aperture, with light-gathering power equivalent to a 5-meter aperture. The details are given in this talk.

1. Scientific Objectives

The main objective of CGST is to observe the solar vector magnetic field, velocity, and the thermodynamic structure with 20 km spatial scale and 1 Sec temporal scale to get systematic and quantitative results on solar MHD processes.
CGST can determine the origin of small-scale magnetic field and the local dynamo process and quantitatively understand the process of 1ower atmospheric magnetic reconnection. It can reliably diagnose the coupling process between solar flare, CME, Solar wind and the small-scale magnetic field, mass flow, etc. It can also reveal the mode of energy transport and mass flows from the lower photosphere to the corona. Furthermore, it can also give an understanding to the cause of solar eruptive activity, and provide a new physical method and a tool to forecast solar activity and space weather.

2. Brief Description of CGST's Performances

The basic idea of CGST is to match the capabilities of DKIST and EST and also to enhance the observational capability in longer wavelength. Hence, CGST is defined as an infrared and optical solar telescope.
The performance of CGST is defined as follows:
CGST is a kind of Ring Solar Telescope (RST) whose diameter is 8 m (spatial resolution is $0.0125''$@400 nm). The effective light gathering area is 22 m^2 (equivalent to a 5 m full-aperture telescope) with the spectral converge of 0.4 to 15 μm and a normal FOV of $3' \times 3'$. The polarization measurement can approach 2×10^{-4}. The spatial resolution

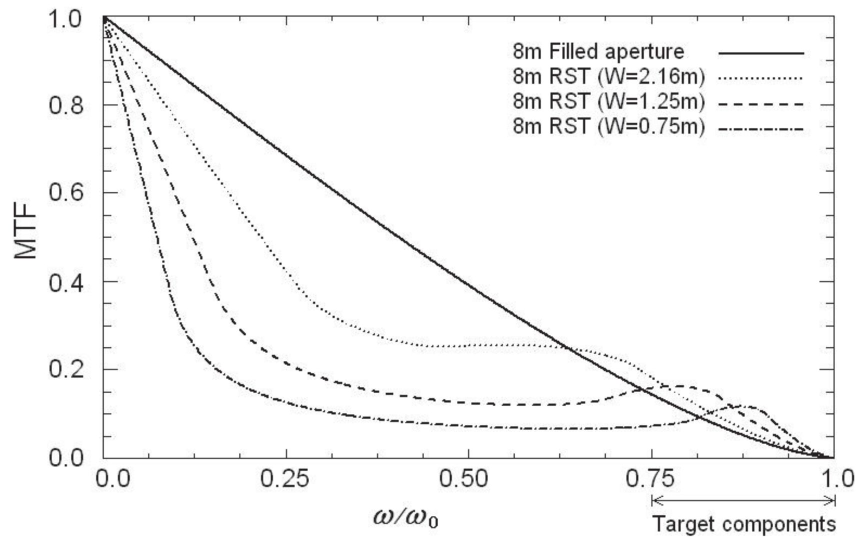

Figure 1. Simulation of RST's MTF with different ring's width.

is 0.03″@1μm (~20 km) and the temporal resolution is 1 s for imaging and 10 s for magnetic field measurement.

3. Progress

3.1. Design of Ring Solar Telescope (RST)

The reason for designing RST is that it gives enough space to realize the thermal control, the optical system is also symmetric which gives least instrumental polarization and the high frequency components which are very important for high resolution observation also increases. Figure 1 shows the simulation of different kind of RST MTF. It could be seen that in the case of sufficient photons, the narrower the ring, higher the high-frequency information. At this position, the ring aperture is a high-pass spatial filter and RST is in fact an optical interferometer. We select a width of 1.2 m width for CGST.

Few years back, we finished simulation of active control, AO/MCAO, system polarization matrix, thermal control and finite element. Figure 2 is a potential choice of RST for CGST.

3.2. Development of Mid-infrared Prototype

The magnetic field is considered to be the first observable in solar physics. In the measurement of solar magnetic field, spatial resolution and polarization accuracy are two of the most important parameters. In the past decades, methods and technologies for high spatial resolution observation enabled us to approach the so-called "magnetic element"

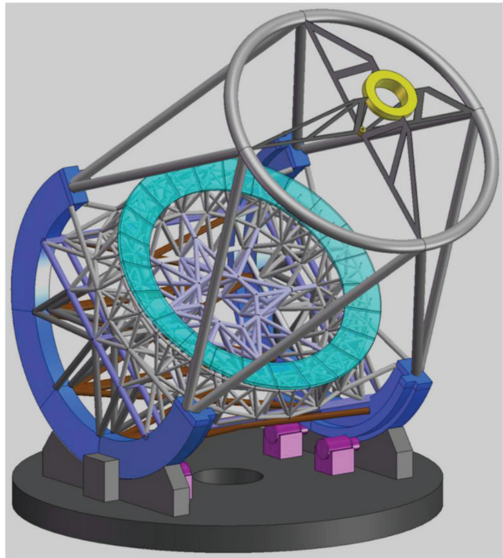

Figure 2. A proposed sketch of CGST. The colored figure can be found in the electronic version.

scale, i.e., the smallest spatial scale of basic magnetic structures. However, the progress in high accurate polarimetry was limited in the past decades.

By means of mid-infrared spectral observation, one can get much larger Zeeman split. In this case, the sensitivity of magnetic measurement can be largely improved. We have proposed a project to realize the "Accurate Infrared Magnetic field Measurements of the Sun", AIMS (see Figure 3).

The performances of AIMS are as follows:

Working spectral line: MgI 12.32μm
Detect sensitivity of magnetic field: 10G
Polarization Accuracy: 10^{-3} Ic
Spectral resolution: 0.6Å with a customized IR FTS (FTIR)
Diameter of telescope: 1.1m
FOV: $192'' \times 192''$
Spatial resolution: $1.5''$ /pixel
Temporal resolution: 30s
The AIMS will also have a wide-band imager, which works at wavelength of 8–10μm, with FOV $384'' \times 384''$, and temporal resolution of 20ms.

The AIMS has been supported by the National Natural Foundation of Sciences of China (NSFC) with 92.56M RMB (about 12M Euro). The period of development is from 2015-2019. It will be installed in the same site where CGST is finally decided to be placed.

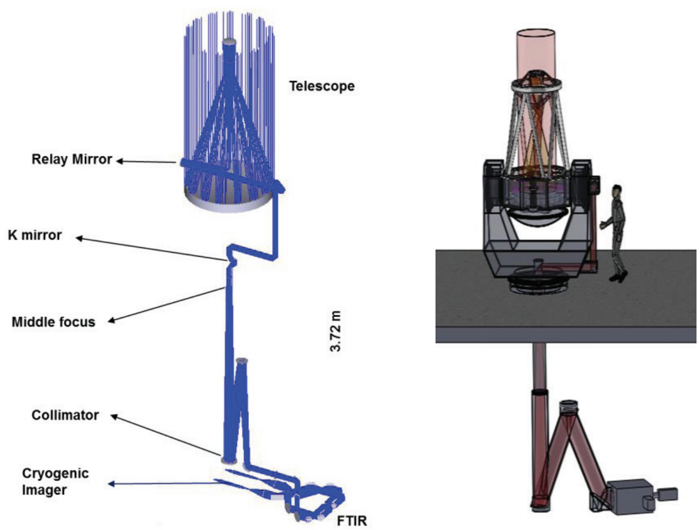

Figure 3. Sketch of AIMS. The colored figure can be found in the electronic version.

3.3. Development of IFU Spectro-polarimeter

In 2015, NSFC supported a project named as "Fiber Arrayed Solar Optic Telescope" (FASOT) with 8.8M RMB. FASOT is an IFU spectro-polarimeter, which has the following scientific objectives: reveals the mechanisms causing the solar eruptions by recovering the stratification of magnetic field, line-of-sight velocity through real time spectro-imaging-polarimetry of multiple magneto-sensitive lines forming in different heights in solar photosphere and chromosphere, and discoveres the fast variations related to magnetic field relying on high temporal resolution in a limited FOV.
Similar to AIMS, FASOT is also a key technology of CGST. Its performance is defined as follows:

Spatial resolution: $1.0''$@ 520.0 nm
Each lenslet covers $0.5''$
FOV of IFU: $30.0'' \times 30.0''$, IFU size 60×60
FOV after scanning: $2'$ (generally), $4' \times 4' = 16$ scannings
Temporal resolution: 3 seconds
Spectral res. power: $> 100,000$@520.0 nm
Polarimetric accuracy: 8.0 E-4
Band of the first priority: 516.5 nm – 525.5 nm
Pointing accuracy: $0.5''$. Tracking accuracy: $0.5''$@30 min.

The sketch of FASOT is shown in Figure 4.

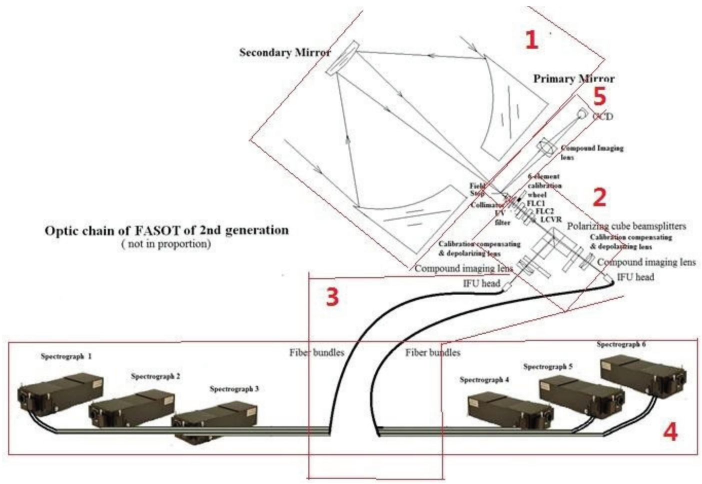

Figure 4. Sketch of FASOT. The colored figure can be found in the electronic version.

Figure 5. Site-survey stations in a mountain-site (left) and a lake-site (right). The colored figure can be found in the electronic version.

3.4. Site Survey

Since 2009, Chinese solar community commenced the site survey for the next generation big solar telescope and coronagraph. By means of meteorological data, the south-west part of the China was selected as the final candidate. By 2014, the site-survey groups finished the reconnaissance in this area.

The general site survey was finished at the end of last year. The initial results were positive with seeing. From then on, the candidates were reduced from many to a lake site (30.7°N, 4700m, Namco Lake) and a mountain site (29°N, 4500m, Wumingshan Mt.). At present the long-term monitoring is still in progress. Figure 5 shows these two candidates.

As of now, the solar site survey have been supported by several financial sources, including NSFC, CAS (Chinese Academy of Sciences), and MOST (Minstery of Science and Technology), with about ten million of RMB. We refer the interested reader to Liu et al. (2014); Qu (2011); Qu et al. (2014).

4. Summary

In 2011, CGST was selected and recommended to National Development and Reform Commission (NDRC) as a candidate of "National major basic scientific project for 2016-2030". In 2013, CGST was listed as one of the future National science projects by NDRC.
The preliminary research on CGST is still in progress. We expect it to get selected for "National major basic scientific project" for the 14th five-year-project plan of China, for the period of 2021-2025.

Acknowledgments. The preliminary research on CGST has been supported by a series of grants from NSFC, MOST, and CAS.

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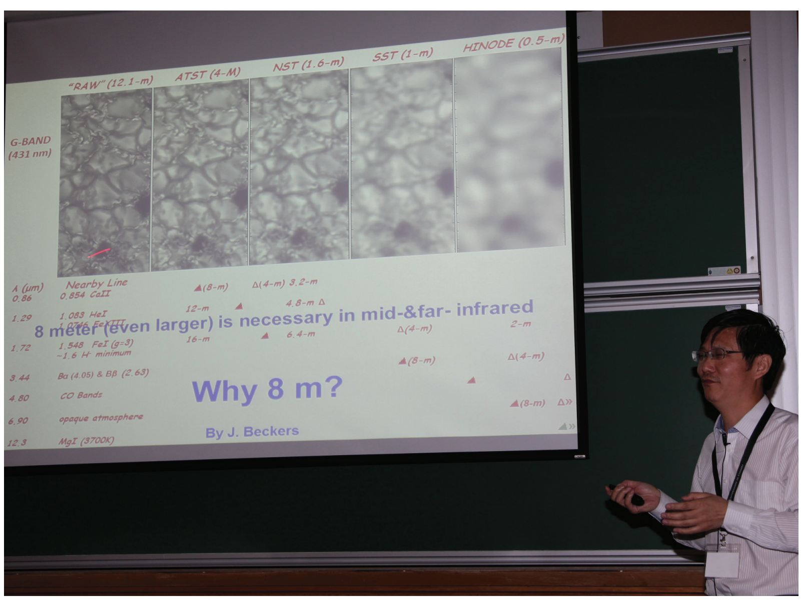

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