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First light of the 1.8-m solar telescope–CLST

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Large-aperture solar telescopes play an important role in solar observations and research, and require high temporal and spatial resolution [1]. To solve some fundamental problems such as the solar dynamo, coronal heating, and the triggering of major solar eruptions, the spatial resolution for solar-atmosphere observation should reach at least 0.1 arcsec [2]. For this goal, solar telescopes with apertures larger than 1 m are required to resolve fine structures in the solar atmosphere. Motivated by these requirements, several large solar telescopes have been built, including the 1-m New Vacuum Solar Telescope [3], the 1.5-m GREGOR Solar Telescope [4], and the 1.6-m Goode Solar Telescope [5]. There are also several other solar telescopes being built, such as the 4-m Daniel K. Inouye Solar Telescope (DKIST, which will be finished in July 2020) [6], the 4-m European Solar Telescope [7], and the 2.5-m WeHit Solar Telescope [8].

The Chinese Large Solar Telescope (CLST) was proposed in 2012. Its main scientific goals are to achieve high-resolution and high-accuracy measurements of vector magnetic fields, thermal and velocity structures, and other dynamic parameters in the solar atmosphere. The CLST's primary mirror has a physical aperture size of 1.8 m, with a 1.76-m clear aperture. It adopts a classic on-axis Gregorian optical configuration, which has advantages (such as easy telescope alignment and polarization calibration, loose integration requirements, and compact size) and disadvantages (central obscuration and spider blocking of incoming light and degradation of telescope MTF), in contrast with the off-axis configuration. Three light-weighted power-reflective mirrors were made of ultra-low-expansion (ULE) material by reducing the weight by more than 70%. Active thermal-control systems for the primary mirror and the heat-stop maintain good thermal performance [9,10]. A high-order adaptive optics system has been installed on the CLST to correct dynamic and static aberration for near diffraction-limited imaging. A multi-wavelength-imaging system was developed as the first-light instrument to observe solar features at the photosphere and chromosphere layers simultaneously, and it will also be used to measure the velocity field at the chromosphere layer and the magnetic field at the

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photosphere after equipping tunable narrow-band filters and polarimetry. The optical configuration and structure design have been described in detail by Rao et al. [1]. After approximately 7 years, the main components of the CLST were manufactured before mid-2019, and they were integrated and aligned successfully between Fall 2019 and by the end of the year. The selected site for the CLST is located on Wuming mountain (N29º9′6″, E100º4′24″), Sichuan province, southwest China. However, the observatory building is still not finished. Thus, Muma mountain (N30º30′21″, E104º0′3″) in Chengdu city that is located at the Institute of Optics and Electronics (IOE), Chinese Academy of Sciences (CAS), is selected as a temporary site.

In the first light, the CLST equips a Ground Layer Adaptive Optics (GLAO) system with a 9×9 array multi-direction Shack-Hartmann wavefront sensor (MD-SHWFS), a 451-actuator deformable mirror (DM), and a real-time controller to correct the static and dynamic wavefront aberration using solar granules as the beacon. A multi-wavelength imaging system including three channels (i.e., G-band, Hα line, and TiO band) currently serves as the first-light instrument. The first light of the 1.8-m solar telescope CLST with a GLAO system and a three-channel imaging system was achieved on December 10, 2019, and the high-resolution-imaging results of the solar photosphere and chromosphere, shown in Figure 1(a), were acquired. It can be seen that the image quality is improved by the GLAO correction. Applying a speckle-reconstruction technique on the GLAO system, a still higher resolution solar image in Figure 1(b) is obtained.

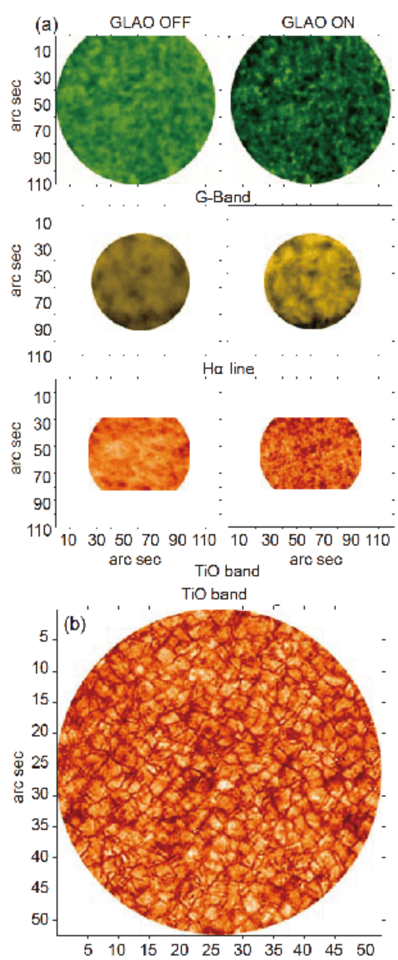

Figure 1 (Color online) First-light observational results of the CLST. Observation results before and after GLAO correction (a) and reconstruction result in the TiO band after GLAO correction (b).

The CLST has, to our knowledge, become the largest solar telescope built thus far in the world, and will remain so until the US DKIST comes online. The CLST is also the first 2-m-class solar optical telescope in China, and it will be used in uninterrupted solar observations together with other large solar telescopes as a network.

This news reports only the CLST first light results. The performance of the whole system will be introduced in a future paper.

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