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Status of the Advanced Space-based Solar Observatory*

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Abstract The Advanced Space-based Solar Observatory (ASO-S) was formally approved at the end of 2017. In the past two years, ASO-S underwent its official Phase-B and Phase-C studies. The Phase-B study was successfully accomplished by the end of April 2019, and the Phase-C study is being now undertaken until August 2020. Then the flight model is planned to finish within 16 months. Around the end of 2021, ASO-S will be ready in the launch state. We briefly summarize the history of ASO-S, the phase-B studies, and the phase-C studies.

Key words Space astronomy, Solar physics, Spacecraft

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1 Brief History of ASO-S

The idea of Advanced Space-based Solar Observatory (ASO-S) was proposed in 2010, referring partially to SMESE, a joint Chinese-French mission[1]. Then in 2011 ASO-S was selected to do concept study (Phase-0/A) by a new program named as Strategic Priority Research Program of Space Science sponsored by the Chinese Academy of Sciences (CAS). Two years later, ASO-S satisfactorily finished the concept study and was successfully selected to undertake further intensive study (Phase-A/B) supported by the same channel. During that period, NNSFC (National Natural Science Foundation of China) provided even stronger financial support to ASO-S. In April 2016, ASO-S got a good mark in an assessment report issued by a top level committee organized by NSSC (National Space Science Center, CAS). Supported continuously by NNSFC, at the end of 2017 ASO-S was formally accepted by CAS after a serious competition with other candidates. Since then ASO-S has been going into the engineering study of official Phase-B and subsequent Phase-C.

There are three payloads on ASO-S, which are the Full-disc vector MagnetoGraph (FMG), the Lyman-alpha Solar Telescope (LST), and the Hard X-ray Imager (HXI), respectively. For the first time in a single platform they will simultaneously observe the solar magnetic field, non-thermal image of solar flares, and the initiation of Coronal Mass Ejection (CME) and its early propagation, so as to study the relationships among solar magnetic field, solar flares, and CMEs. Explicitly, four major scientific objectives can be described as: (i) to observe simultaneously non-thermal images of solar flares in hard X-rays, and the initiations of CME in Lyman-alpha waveband, in order to understand the relationships between flares and CMEs; (ii) to observe simultaneously full-disc vector magnetic field, energy build up and release of solar flares, and the formation of CMEs, in order to understand the causality among them; (iii) to observe the response of solar atmosphere to the eruptions, in order to understand the mechanisms of energy release and transport; (iv) to observe solar eruptions and the evolution of magnetic field, in order to provide clues for forecasting space

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In November 2019, a special issue about ASO-S, including a total of 14 papers[2-15], was published in Research in Astronomy and Astrophysics (RAA). These papers summarized comprehensively the general framework, the scientific objectives, systematic designs, the payload schemes, prototype models, engineering models, scientific systems, the synthetic studies, and so on, up to the end of Phase-B and the beginning of Phase-C. The readers are encouraged to refer to that special issue for more details. We here mention briefly only the rough milestones in chronological order for the past two years.

2 Phase-B Studies

Officially, the Phase-B studies continued 16 months, from January 2018 to the end of April 2019. During this period, the work focused mainly on the satellite system, including the payloads.

2.1 Satellite System in Phase-B

Besides coordinating all the issues related to payloads, the satellite system has its own tasks like mission requirement analysis, preliminary scheme design, key technology solutions, validating experiments, and so on. Quite a number of documents were generated during this period, which summarized the tasks done and provided the scheme for the following works. Although the platform does not seem to be special, all the sub-systems should be considered and designed. How to ensure all the payloads pointing to the Sun with rather high accuracies is one of the key issues, which was finally solved through both smart design and process control. The whole architecture of the mission was mechanically experimented at the beginning of 2019. The evaluation on the entire work of the Phase-B was passed at the end of April 2019.

2.2 Payloads in Phase-B

The requirement analysis was first finished in the initial stage of this period. Besides the interface parameters like weight, power, and dimensions, the detailed specification parameters of all three instruments were definitely defined. The solutions of key technologies for each payload are the main work during Phase-B. For the FMG, the key issues include the entrance window, imaging stabilization system, the bubble suppression in the filter, and so on. For the LST, the key issues include the suppression of stray-light, the measurement of stray-light, imaging stability, and so on. For the HXI, the key issue is concerned about the assembly of the grids, like grid stack technique, the alignment of front and rear grids, the stability of collimator, and so on. All of these key technologies were properly identified during the Phase-B. The engineering proto-type models of the FMG, LST, and HXI were produced and tested. The integration of the payloads with the platform was also performed and some experiments like assembly, mechanics, vibration, thermal control were carried out.

3 Phase-C Studies

Officially, the Phase-C studies started from May 2019 and will finish at the end of July 2020. During this period, besides the satellite system, the scientific application system (including science preparations) has also been put on the agenda.

3.1 Satellite System in Phase-C

Based on the work done in Phase-B, at the beginning of Phase-C, the satellite system finished and improved the design of the whole platform, including seven subsystems of Mechanics, Thermal Control, AOCS, Electrical Power, OBDH, TT&C, and Data Transmission. The interfaces with other systems and detailed schedule were drawn up. Then the individual parts have been under fabrication. In July 2019, the electric performances of the platform together with all three payloads were jointly debugged. The integration and test work is scheduled to start no later than March 2020. All the work related to the qualification model is planned to finish by the end of July 2020.

3.2 Payloads in Phase-C

Like the satellite system, the schematic designs for FMG, LST, and HXI were first improved and finished. Then the individual parts for these three instruments were in parallel manufactured and the assembly for each instrument has almost been com-

pleted by the end of December 2019. As of the time of writing (the end of January 2020), the experiment, calibration, and environment tests are being done for these instruments separately. In March 2020, the qualification models of FMG, LST, and HXI will be delivered to the satellite system for integration and the overall test.

3.3 Scientific Issues

Besides the hardware work, scientific preparations have also been progressing for quite a time. Two major research grants were provided by NNSFC and CAS respectively. The science team, led by the chief scientist of ASO-S, was organized, which focuses mainly on the data deductions and usages for the outputs of the payloads in the future. Certainly, this kind of work is closely related to the Science Operation and Data Center (SODC)[11], which consists in fact four divisions: scientific operation, data management, data analysis center, and user service. So far SODC has finished its schematic design and the software work has started accordingly. Besides, the first ASO-S international workshop was held in 15–18 January, 2019 at Nanjing. More than 100 participants from over ten countries attended the meeting.

4 Conclusions

By now ASO-S is undertaking its Phase-C study. All the works look smooth and are on the track of the schedule, although the timetable shows a little tense sometimes. It is expected that the flight model can be started from August 2020 and then at the end of 2021 or in the early of 2022, ASO-S could be launched. In this period, the special issue of ASO-S[2-15] is highly recommended to the readers who would like to know more details about the mission.

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