

Progress Report on ASO-S: 2024—2026*

SU Yang GAN Weiqun

(Division for Dark Matter and Space Astronomy, Purple Mountain Observatory, Chinese Academy of Sciences, Nanjing 210023)

Abstract This paper report on the progress of the Advanced Space-based Solar Observatory (ASO-S) mission and the related research. ASO-S was launched on 9 October 2022. Since the end of the commissioning phase at the end of July 2023, the three scientific payloads FMG, LST, and HXI have obtained unique datasets of solar activities, including X-ray flares, 360 nm white light flares, Coronal Mass Ejections (CMEs), filament eruptions, Ly α brightenings, *etc.* The data products and event lists have been released. The in-orbit tests and calibrations carried out during the commissioning phase, as well as the early results based on the ASO-S data, a total of 30 papers, were published in a topical collection of *Solar Physics* between 2023 and 2025. In total, more than 180 papers related to ASO-S have been published.

Key words Space astronomy, Solar physics, Spacecraft, Solar flares, CMEs, Solar X-ray bursts

Classified index P171

1 Introduction

ASO-S is China's first comprehensive solar observatory in space^[1–4]. It has three scientific payloads FMG, HXI, and LST, designed to observe solar magnetic field, hard X-ray bursts of flares, 360 nm white light flares, Ly α activities, and CMEs.

This is the fourth report on ASO-S progress during 2024—2026, as a part of the CNCOSPAR national report series. The previous reports^[5–7] provided an overview of the ASO-S project, including the history and background of the proposal, the Phase-B, the Phase-C, the Phase-D, the launch, the commissioning phase, and some early research based on ASO-S data.

2 ASO-S Observations and Event Lists

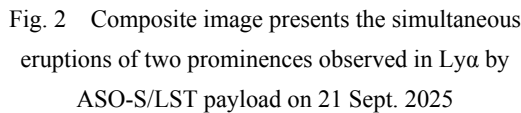
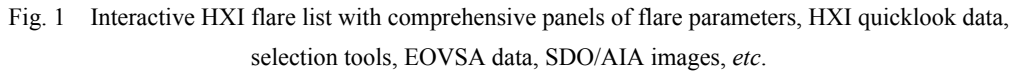
ASO-S has been observing the Sun since its launch in

Oct. 2022 and obtained unique datasets of solar activities of the current 25th solar cycle, including more than 80 X-class flares. A number of event lists have been established or released, such as LST/WST 360 nm white light flares (more than 500 events), LST/SDI Lyman-alpha Solar Flares (more than 5000 events. <http://aso-s.pmo.ac.cn/event/sdiFlareListMonthly.jsp>), HXI hard X-ray bursts (more than 2100 events. http://aso-s.pmo.ac.cn/hxi_flare/hxi_flare_list.html), and LST/SCI prominence events (<http://aso-s.pmo.ac.cn/sodc/sciuv-Data.jsp>). In particular, the list of HXI hard X-ray bursts developed by Yu *et al.* is not only a list of HXI flares, but also an interactive tool (see Figure 1) for browsing the quicklook data of HXI, SDO/AIA, and EOVS, and for selecting specific flares for statistical studies. In addition, a comprehensive database has been established for Extreme Solar Eruptions (<http://aso-s.pmo.ac.cn/event/index.jsp>). An example of erupting prominences and the Sun in Ly α is shown in Figure 2.

* Supported by the Strategic Priority Research Program of the Chinese Academy of Sciences (XDB0560000, XDA15320000), the National Key R&D Program of China (2022YFF0503000), and the National Natural Science Foundation of China (12333010, 12233012, 11921003)

Received May 20, 2026

©The Author(s) 2026. This is an open access article under the CC-BY 4.0 License (<https://creativecommons.org/licenses/by/4.0/>)



(Groups 1 and 2) is still under testing, at a stage comparable to that for STIX grid Groups 1 and 2. LST released Level 1.2 data, which is improved from Level 1 based on a machine learning method^[8]. LST also released SCI data of ten events.

Beyond monitoring solar activity, ASO-S has also observed other astronomical events, such as sun-grazing comets. On 4 April 2026, ASO-S/LST/SCI observed the Comet C/2026 A1 (MAPS) within a close distance of ~ 1.2 to 2.5 solar radii from the Sun's center. Therefore, unique dual-wavelength images of the comet in white light (700 ± 30 nm) and Ly α (121.6 nm) are obtained, providing a valuable opportunity for studying Sun-grazing comets and corona.

Although the commissioning phase concluded at the end of July 2023, the associated papers on in-orbit tests were published intermittently from 2023 to 2025, as part of the topical collection in Solar Physics entitled “ASO-S Mission: Inflight Performance and First Results”.

The overview of ASO-S and the first light images are presented in Gan *et al.*^[4]. The details of the inflight testing and calibrations carried out during the commissioning phase for the FMG, HXI, and LST payload can be found in Bai *et al.*^[9], Su *et al.*^[10], and Chen *et al.*^[11], respectively. The latest status for the Science Operation and Data Analysis Center (SODC) of ASO-S can be found in Huang *et al.*^[12]. SODC now provides data services to about 150 registered users from 13 countries.

4 Early Results

Here we present a few studies with ASO-S data. Based on the FMG synoptic magnetograms, Chen *et al.*^[13] developed a comprehensive analysis tool FastQSL 2 for global magnetic connectivity, which has important applications in identifying magnetic reconnection sites and predicting solar wind speed. Li *et al.*^[14] obtained the first Ly α Carrington map based on LST data, a key input for studies of Ly α corona. Wang *et al.*^[15] revealed the origin of the October 2024 super geomagnetic storm with the key observations from the ASO-S/LST White-Light Coronagraph, which fills the observational gap between EUV Imaging and traditional coronagraphs from the Earth's perspective. Based on HXI data, Chen *et al.*^[16] did a statistical study of energetic C-class flares, *i.e.*, C-class flares with significant X-ray flux above 30 keV, and found that only 5 of the 127 events are associated with CMEs, much lower than the expected rate from standard models and previous studies. This is an important result under the key scientific objectives (the nature of the solar magnetic field, flares, CMEs and their relationship) of ASO-S. More description of the early results of ASO-S can be found in Gan *et al.*^[17].

4.1 White Light flares

Jing *et al.*^[18] reported, for the first time, the occurrence rate of white-light flares at 360 nm (23.9%), revealing that such flares are not rare. This work was marked by the editor's choice. Jing *et al.*^[19] further found that white-light flares in super active regions exhibit unique properties.

4.2 Quasi-Periodic Pulsations (QPP)

QPPs are a common feature of flares seen in different wavelengths. With HXI X-ray data, QPPs have been extensively investigated. For example, Li *et al.*^[20] reported

QPPs with a long period of about 200 s in HXR, microwave, and Ly α emissions of an X6.4 flare, and the associated sources were identified in HXR images. The long period is probably modulated by the slow magnetoacoustic wave originating from the neighboring sunspot. In another work, Li *et al.*^[21] localized the flare QPP at a shorter period of about 1 s in the high-energy channels of HXRs and Gamma-ray continuum during an X9.0 flare, which may be interpreted by the interacting loop model. Ashfield *et al.*^[22] investigated spectroscopic and X-ray observations of QPPs in a solar flare and found that the downwards velocities in the flare ribbon are periodically driven by a modulated deposition of accelerated electrons in the chromosphere as a result of repeated reconnection. This work was published in Nature Astronomy in 2026.

4.3 Stereoscopic Studies with ASO-S Data

The launch of ASO-S, in conjunction with Solar Orbiter, has enabled stereoscopic imaging observations of the Sun in both Ly α (LST and Metis) and hard X-rays (HXI and STIX), leading to studies of three-dimensional (3D) properties of flares and eruptions, *e.g.* Ryan *et al.* 2024^[23] and Mrozek *et al.* 2024^[24]. Moreover, Palumbo *et al.*^[25] successfully reconstructed the first 3D image of the HXR source in a flare from the HXI and STIX data. Su *et al.* (under review) reported the first detection of strong anisotropy in the flare X-ray emissions received by HXI and STIX and obtained the pitch-angle distributions of the associated energetic electrons. Zhang *et al.*^[26] tracked the 3D propagation of an erupted prominence using multi-viewpoint observations from SolO/EUI, ASO-S/LST/SCI, and GOES-16/SUVI. These studies highlight the value and significance of stereoscopic observations and offer scientific guidance for China's future deep-space solar missions, including SPO and LAVSO.

4.4 AI-Empowered Studies

Artificial Intelligence (AI) has emerged as an increasingly powerful tool for both data processing and scientific research in Astronomy. Related AI-driven methods and models, such as machine learning, have been extensively applied within the ASO-S mission, though so far primarily confined to data processing, feature recognition, and calibration. These works include the calibration of FMG magnetic field data^[27,28], the improvement of LST

images^[8] leading to the production and release of LST level 1.2 data, the first HXR image reconstruction algorithm based on deep learning^[29], and AI prediction of background profiles of 91 HXI imaging detectors (Liu *et al.* in prep.).

5 Research Coordination and International Collaborations

The second joint science assembly between ASO-S and CHASE was successfully held in Suzhou on 11–14 May 2025. Over 200 domestic participants attended the event, and 126 presentations were made. This conference has become one of the most important meetings of the solar physics community in China.

ASO-S mission has an open data policy and encourages international collaborations. In 2023, the ASO-S team launched its own program, *i.e.*, the ASO-S Guest Investigator Program (AGIP), to support international collaborations and enhance the scientific output of ASO-S data. By the end of April 2026, AGIP had supported 18 visits (including repeat visits) to the SDOC at Purple Mountain Observatory. These visitors come from seven countries to conduct independent or collaborative research based on or related to ASO-S data. A total of 41.5 man-months have been invested through AGIP, resulting in more than ten papers that are either published or in preparation.

Since the development phase of ASO-S instruments, stable collaborative relationships, regular online discussion mechanisms, and frequent reciprocal visits have been established between the HXI and STIX teams, and between the LST and Metis teams. We believe that international collaborations have been and will always be the best way and the right way for efficiently exploring the universe and conducting scientific research.

6 Conclusions

As the ASO-S continues collecting data of solar activities during the maximum of the 25 th solar cycle, we expect breakthroughs in the upcoming years in studies of flare energy release, energetic electrons, magnetic cause of solar eruptions, nature of white light flares, as well as Ly α enhancements.

Conflict of Interests The authors declare that there is no conflict of interests

References

- [1] GAN W Q, ZHU C, DENG Y Y, *et al.* Advanced Space-based Solar Observatory (ASO-S): an overview[J]. *Research in Astronomy and Astrophysics*, 2019, **19**(11): 156
- [2] GAN W Q, FENG L, SU Y. A Chinese solar observatory in space[J]. *Nature Astronomy*, 2022, **6**(1): 165
- [3] GAN W Q, ZHU C, CHEN B, *et al.* China's first comprehensive space solar observatory[J]. *Chinese Astronomy and Astrophysics*, 2023, **47**(2): 441-445
- [4] Gan W Q, Zhu C, Deng Y Y, *et al.* The Advanced Space-based Solar Observatory (ASO-S)[J]. *Solar Physics*, 2023, **298**(5): 68
- [5] GAN W Q. Status of the advanced space-based solar observatory[J]. *Chinese Journal of Space Science*, 2020, **40**(5): 704-706
- [6] GAN W Q. Progress report on ASO-S[J]. *Chinese Journal of Space Science*, 2022, **42**(4): 565-567
- [7] GAN W Q. Progress report on ASO-S: 2022-2024[J]. *Chinese Journal of Space Science*, 2024, **44**(4): 687-689
- [8] LIU H, LI H, ZOU S Z, *et al.* Improving image quality of the Solar Disk Imager (SDI) of the Ly α Solar Telescope (LST) on-board the ASO-S mission[J]. *Research in Astronomy and Astrophysics*, 2025, **25**(2): 025005
- [9] BAI X Y, DENG Y Y, ZHANG H Y, *et al.* Calibration and performance of the Full-disk vector MagnetoGraph (FMG) on board the Advanced Space-based Solar Observatory (ASO-S)[J]. *Solar Physics*, 2024, **299**(11): 157
- [10] SU Y, ZHANG Z, CHEN W, *et al.* The tests and calibrations of the hard X-ray imager aboard ASO-S[J]. *Solar Physics*, 2024, **299**(10): 153
- [11] CHEN B, FENG L, ZHANG G, *et al.* Inflight performance and calibrations of the Lyman-alpha solar telescope on board the advanced space-based solar observatory[J]. *Solar Physics*, 2024, **299**(8): 118
- [12] HUANG Y, LI Y P, LIU S, *et al.* Science operation and data analysis center of the Advanced Space-based Solar Observatory (ASO-S) mission[J]. *Solar Physics*, 2024, **299**(9): 135
- [13] CHEN J, WIEGELMANN T, FENG L, *et al.* FastQSL 2: a comprehensive toolkit for magnetic connectivity analysis[J]. *SCIENCE CHINA Physics, Mechanics & Astronomy*, 2023, **66**(1): 15
- [14] LI S T, FENG L, YING B L, *et al.* Carrington maps in H β Ly α and their relationships with extreme-ultraviolet and magnetic-field maps[J]. *The Astrophysical Journal Letters*, 2024, **969**(1): L16
- [15] WANG R, HU H D, ZHAO X W, *et al.* A major geomagnetic storm in 2024 October linked to sympathetic coronal mass ejection–prominence eruptions[J]. *The Astrophysical Journal Letters*, 2026, **1002**(1): L23
- [16] CHEN C X, SU Y, CHEN W, *et al.* Intense hard X-ray emissions in C-class flares: a statistical study with ASO-S/HXI data[J]. *The Astrophysical Journal Letters*, 2025, **987**(1): L4
- [17] GAN Weiqun, SU Yang, FENG Li, *et al.* Brief review on early

- achievements of ASO-S in orbit[J]. *Science & Technology Review*, 2025, **43**(16): 43-61 (甘为群, 苏杨, 封莉, 等. “夸父一号”(ASO-S) 卫星早期成果概述 [J]. *科技导报*, 2025, **43**(16): 43-61)
- [18] JING Z C, LI Y, FENG L, *et al.* A statistical study of solar white-light flares observed by the white-light solar telescope of the Lyman-alpha solar telescope on the Advanced Space-based Solar Observatory (ASO-S/LST/WST) at 360 nm[J]. *Solar Physics*, 2024, **299**(2): 11
- [19] JING Z C, LI Y, LI J W, *et al.* The M- and X-class white-light flares in super active region NOAA 13664/13697 observed by ASO-S/LST/WST[J]. *The Astrophysical Journal*, 2025, **992**(1): 72
- [20] LI D, HONG Z X, HOU Z Y, *et al.* Localizing quasiperiodic pulsations in hard X-ray, microwave, and Ly α emissions of an X6.4 flare[J]. *The Astrophysical Journal*, 2024, **970**(1): 77
- [21] LI D. Localizing short-period pulsations in hard X-rays and γ -rays during an X9.0 flare[J]. *Astronomy & Astrophysics*, 2025, **695**: L4
- [22] ASHFIELD W, POLITO V, LÖRINČÍK J, *et al.* Spectroscopic observations of solar flare pulsations driven by oscillatory magnetic reconnection[J]. *Nature Astronomy*, 2026, **10**(1): 54-63
- [23] RYAN D F, MASSA P, BATTAGLIA A F, *et al.* Triangulation of hard X-ray sources in an X-class solar flare with ASO-S/HXI and solar orbiter/STIX[J]. *Solar Physics*, 2024, **299**(8): 114
- [24] MROZEK T, LI Z T, KARLICKÝ M, *et al.* Kink-and-disconnection failed eruption in 3D[J]. *Solar Physics*, 2024, **299**(6): 81
- [25] Palumbo B, Massa P, Stiefel M Z, *et al.* 3D reconstruction of thermal hard X-ray sources in solar flares from combined STIX and HXI visibilities. *Astronomy & Astrophysics*, 2026, **710**: A105
- [26] ZHANG Q M, PAN W W, YING B L, *et al.* Tracking an eruptive intermediate prominence originating from the farside of the sun[J]. *The Astrophysical Journal*, 2025, **985**(2): 237
- [27] HU Z Y, JI K F, CHEN J, *et al.* Calibration scheme for space-borne full-disk vector magnetograph under the influence of orbiter velocity[J]. *Astronomy & Astrophysics*, 2022, **666**: A93
- [28] HU Z Y, JI K F, BAI X Y, *et al.* Nonlinear calibration method for FMG line-of-sight magnetic field[J]. *Universe*, 2025, **11**(4): 108
- [29] XIA Y H, SU Y, LIU H, *et al.* A new solar hard X-ray image reconstruction algorithm for ASO-S/HXI based on deep learning[J]. *Solar Physics*, 2024, **299**(11): 158

Author Biography



SU Yang Male, born in Taian, Shandong on 10 April 1982, is currently a research fellow and lead scientist for ASO-S science at Purple Mountain Observatory, Chinese Academy of Sciences. He is also ASO-S/HXI payload scientist and data scientist. His research focuses on solar physics, hard X-ray imaging and related space astronomy.
E-mail: yang.su@pmo.ac.cn