0254-6124/2026/46(4)-0961-04 *Chin. J. Space Sci.* 空间科学学报

WANG Chi, DONG Xiaolong, SONG Tingting, CAO Song, ZHANG Aibing, CHI Yixing. China's "Origins" Space Science Program. *Chinese Journal of Space Science*, 2026, **46**(4): 961–964. CSTR:32142.14.cjss.2026–yg18. DOI:10.11728/cjss2026.04.2026–yg18

China's "Origins" Space Science Program*

WANG Chi DONG Xiaolong SONG Tingting

CAO Song ZHANG Aibing CHI Yixing

(*National Space Science Center*, *Chinese Academy of Sciences*, *Beijing* 100190)

Abstract The "Origins" Program addresses the first-phase objectives to implement the *National Mid- and Long-term Plan for Space Science in China (2024–2050)*, which was released in October 2024. Focusing on fundamental questions concerning the "Origins", this program encompasses four flagship space science satellite missions: Discovering the Sky at the Longest wavelength (DSL), the Solar Polar Orbit Observatory (SPO), the Earth 2.0 (ET) mission, and the Enhanced X-ray Timing and Polarimetry (eXTP) mission. These four missions are targeted for major discoveries and original scientific results on the grand questions about the early universe, space weather, earth-like exoplanets and physics of the extreme universe. By 2025, all four missions have completed the Preliminary Design Phase. These four missions have been scheduled to be launched before 2031.

Key words Space science, Science missions, Early universe, Space weather, Exoplanet

Classified index P353

1 Introduction

In October 2024, China released *National Mid- and Long-term Plan for Space Science in China (2024–2050)*[1], outlining a strategic roadmap for the nation's future space science endeavors. Against this backdrop, the "Origins" Program was proposed and started by the Chinese Academy of Sciences in 2025, which directly addresses the first-phase objectives of the *National Mid- and Long-term Plan for Space Science in China (2024–2050)*. The program is designed to carry out a coordinated set of four space science missions, with a target launch date by 2030. These missions aim to tackle fundamental questions about the early universe, exoplanets, solar activities and space weather, and the physics of extreme celestial objects. It is expected that major discoveries and original results will be achieved by the 2030 s in areas such as the dark age of the universe, the solar magnetic activity cycle and high-speed solar wind, Earth-like exoplanets, and the laws of physics under extreme cosmic conditions.

2 Discovering the Sky at the Longest Wavelength

The Discovering the Sky at the Longest Wavelength (DSL) mission represents a pioneering effort to open a new observational window in ultra-long-wave radio astronomy[2]. The mission adopts a unique constellation architecture consisting of one mother satellite and nine daughter satellites, all operating in a 300 km circular lunar orbit. By leveraging the highly clean electromagnetic environment on the far side of the Moon, DSL is uniquely positioned to conduct high-sensitivity observations at MHz frequencies, enabling breakthrough explorations of the cosmic dark age and dawn.

The scientific objectives of DSL are threefold. First, by performing high-precision measurements of the

* Supported by Program for Seizing the Commanding Heights of Science and Technology (GJ11050402)
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/)

all-sky radio spectrum, the mission aims to provide key observational evidence for revealing the evolutionary history of the cosmic dark ages and cosmic dawn. Second, it seeks to achieve the first high-resolution ultra-long-wave sky survey, thereby opening up a new window for low-frequency radio astronomical observations. Third, DSL will observe ultra-long-wave radio activities of the Sun and its planets, with the goal of uncovering the mechanisms governing their interactions with the interplanetary environment.

To accomplish these scientific objectives, DSL is equipped with two complementary types of payloads designed to operate across the ultra-long-wavelength band. The High Frequency Spectrometer (HFS), equipped on one high-frequency satellite, is configured to detect the power spectrum of cosmic radiation in the 30–120 MHz range with high sensitivity, enabling precise measurements of the radio spectrum. The Distributed Low-Frequency Interferometric Spectrometer (LFIS), equipped on eight low-frequency satellites, is designed to perform high-resolution imaging and spectral measurements across the full sky in the 0.1–30 MHz band, providing the first high-fidelity maps of the ultra-long-wavelength sky.

3 Solar Polar Orbit Observatory

The Solar Polar Orbit Observatory (SPO) is designed to address fundamental questions about the Sun's magnetic activity, solar wind generation, and heliospheric space weather processes[3]. The mission adopts a high-inclination solar polar orbit with an inclination exceeding 75° and an orbital period of less than 1.5 years, enabling unprecedented imaging observations of the solar polar regions. With a planned mission duration of 15 years, including 10 years dedicated to polar observations and over 800 days at latitudes above 55°, SPO will obtain the first frontal imaging of the solar polar regions, providing critical insights into the hidden engine that drives solar activity.

The scientific objectives of SPO are centered around three interconnected themes. First, to unveil the origin of the solar magnetic cycle. The mission aims to unveil the generation mechanism of the poloidal field through high-precision polar magnetic and velocity field observations, and to pinpoint the formation region of the toroidal field via polar helioseismology, thereby providing a complete picture of the solar dynamo process. Second, to understand the generation mechanism of the fast solar wind. SPO will combine polar remote-sensing observations with in-situ measurements to identify the source regions of the fast solar wind and its embedded fine structures, and quantify the relative contributions of magnetic reconnection and wave dissipation to the mass and energy supply of the solar wind. Third, to understand space weather processes in the solar system. The mission will utilize the global magnetic field distribution obtained from polar observations to provide complete initial and boundary conditions for whole-heliosphere MHD models, construct a self-consistent numerical model through iterative validation with multi-wavelength and in-situ data, and quantitatively characterize the three-dimensional structure and propagation of solar wind disturbances, thereby opening a new era of space weather and space climatology studies.

To achieve these ambitious goals, SPO carries a comprehensive suite of remote sensing and in-situ instruments. The remote sensing payloads include the Magnetic and Velocity Field Imager (MHI) for high-resolution, high-sensitivity observations of the photospheric vector magnetic field and Doppler velocity field across the full solar disk; the Extreme Ultraviolet Telescope (EUST) for high-resolution imaging and integrated spectral measurements in the extreme ultraviolet band; the White Light Coronagraph (VISCO) for visible-light imaging of the sub-Alfvénic solar wind from the low to high corona; the Heliospheric Imager (VLACOR) for tracking the propagation and evolution of solar wind structures, including coronal mass ejections, from the outer corona into the inner heliosphere; and the X-ray Imaging Telescope (XIT) for observations of solar high-energy X-ray spectra, light curves, and imaging. The in-situ payloads consist of the Solar Wind Ion Mass Spectrometer (SWIMS) for mass-resolved and angle-resolved measurements of solar wind ions, the Solar Wind Ion Retarding Potential Analyzer (SWIRPA) for fast and long-duration measurements of solar wind ions without degradation, and the Magnetometer (MAG) for precise measurements of the interplanetary magnetic field. This integrated payload suite enables SPO to simultaneously

observe the Sun's polar magnetic field, the acceleration region of the solar wind, and the subsequent propagation of solar wind disturbances through the heliosphere, providing a holistic view of the Sun-heliosphere system.

4 The Earth 2.0

The Earth 2.0 (ET) mission is a space observatory at the Earth-Sun L2 point, designed to conduct a long-term, large-scale survey of exoplanets[4]. Its primary goal is to explore habitable Earth-like planets outside our solar system and to identify promising candidates for future extraterrestrial life searches. The spacecraft will be placed in a halo orbit around L2, providing a stable thermal and viewing environment essential for high-precision photometric observations over extended periods.

ET pursues three primary scientific objectives. First, the mission aims to discover Earth 2.0s—Earth-sized planets orbiting Sun-like stars in the habitable zone—for the first time and to determine their occurrence rate. Second, by discovering a large population of terrestrial planets across a wide range of orbital distances and stellar environments, ET will reveal the statistical distribution and physical properties of the terrestrial-planet population. Third, the mission seeks to detect free-floating Earth-mass planets (rogue planets) for the first time and measure their occurrence rate, shedding light on the formation and ejection history of planetary systems.

To achieve these goals, ET carries two complementary instrument systems. The transit telescope array consists of six 28 cm aperture wide-field telescopes, achieving a photometric precision of 3.4×10^{-5}@6.5 h cumulative exposure. This array will continuously monitor approximately two million FGK stars in the Kepler field and its adjacent regions for four years, using the transit method to search for Earth-like exoplanets. The gravitational microlensing telescope is a 35 cm aperture telescope that will observe at least 30 million stars in the Galactic bulge region over a cumulative two-year period. By monitoring microlensing events and measuring microlens parallax in coordination with the ground-based telescopes, it will detect free-floating Earth-mass rogue planets and characterize their population. Together, the transit and microlensing surveys provide a powerful and complementary approach to discovering both bound terrestrial planets and unbound planetary-mass objects.

5 Enhanced X-ray Timing and Polarimetry

The Enhanced X-ray Timing and Polarimetry (eXTP) mission[5] is an X-ray space observatory designed to conduct research on the detection of dense celestial bodies such as black holes and neutron stars, with high time resolution, high energy resolution, and high-precision polarization. Operating from a circular orbit at 610 km altitude with an inclination of 20°, eXTP will explore the physical laws and principles under the extreme conditions in the universe, including extreme gravity, extreme magnetism, and extreme density. The mission will address fundamental questions such as: What happens near a black hole? What is the internal structure and composition of neutron stars? What are the properties of vacuum fluctuations in strong magnetic fields? By combining high-precision timing, spectroscopy, and polarimetry, eXTP will reveal how matter behaves in the most extreme environments ever observed.

The key scientific objectives of eXTP include: studying black hole and strong gravity physics *via* observing black hole accretion processes and exploring matter dynamics in strong gravity fields; studying magnetar and extreme magnetic field physics *via* observing magnetar vacuum polarization and measuring quantum electrodynamics effects in radiation from these stars; determining the dense matter equation of state (especially at supra-nuclear densities) and studying neutron star and extreme density physics *via* precise neutron star mass and radius measurements; and studying extreme condition physics *via* X-ray counterpart observations of gamma-ray bursts, gravitational wave bursts, high-energy gamma-ray and neutrino sources in the 2030s.

To achieve these goals, eXTP carries two complementary focusing telescope arrays. The Spectroscopy Focusing Array (SFA) consists of six X-ray telescopes designed to perform high-sensitivity spectroscopy and timing measurements across the X-ray band. The Polarimetry Focusing Array (PFA) comprises three X-ray telescopes dedicated to high-precision X-ray polarimetry. Together, these instruments enable simultaneous

measurements of spectral, timing, and polarimetric signatures from compact objects, providing a powerful and comprehensive probe of extreme physics in the universe.

6 Mission Progress

As of 2025, all four missions—DSL, SPO, ET, and eXTP—have successfully completed the Preliminary Design Phase (Phase B) and are advancing in parallel toward their respective launch readiness milestones.

In 2026, the Pathfinder-1 satellite will be launched to perform in-orbit validation of critical technologies for the main missions. All four satellites are scheduled for launch before 2031. After the launch, nominal observations will be conducted in succession and scientific data will be achieved, with the goal of delivering major discoveries and high-impact scientific results.

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

References

[1] Chinese Academy of Sciences; National Space Administration of China; China Manned Space Engineering Office. National Mid- and Long-term Plan for Space Science in China (2024-2050) [EB/OL]. (2024-10-16)[2026-04-01] https://www.gov.cn/lianbo/bumen/202410/content_6980618.htm

[2] CHEN Xuelei, YAN Jingye, DENG Li, *et al*. 2021 Discovering the sky at the longest wavelengths with a lunar orbit array[J]. *Philosophical Transactions of the Royal Society A*, 2021, **379** (2788): 20190566

[3] DENG Yuanyong, ZHOU Guiping, DAI Shuwu, *et al*. Solar polar-orbit observatory[J]. *Chinese Science Bulletin*, 2023, **38**(4): 298-308 (邓元勇, 周桂萍, 代树武, 等. 太阳极轨天文台 [J]. 科学通报, 2023, **38**(4): 298-308)

[4] GE Jian, ZHANG Hhui, DENG Hongping, *et al*. The ET mission to search for Earth 2.0 s[J]. *The Innovation*, 2022, **3**(4): 100271

[5] ZHANG Shuang-Nan, SANTANGELO Andrea, XU Yupeng, *et al*. The enhanced X-ray Timing and Polarimetry mission—eXTP for launch in 2030[J]. *Science China Physics, Mechanics & Astronomy*, 2025, **68**(11): 119502

Author Biography



WANG Chi The Director of the National Space Science Center, Chinese Academy of Sciences (CAS), and an Academician of CAS and the International Academy of Astronautics. He received his bachelor's degree from the University of Science and Technology of China in 1990 and his Ph.D. from the Massachusetts Institute of Technology in 1998. His research focuses on space physics and space weather. He currently serves as Chief Scientist of Phase IV of China's Lunar Exploration Program, the Chinese Principal Investigator of the Solar Wind Magnetosphere Ionosphere Link Explorer (SMILE) mission, and Commander-in-Chief of Phase II of the Chinese Meridian Project. His honors include the Special Prize of the National Science and Technology Progress Award, the Qian Xuesen Outstanding Contribution Award, and the First Prize of the Science and Technology Progress Award of the Chinese Geoscience Union.
E-mail: cw@spaceweather.ac.cn