OVERVIEW OF CHINA'S UPCOMING CHANG'E SERIES AND THE SCIENTIFC OBJECTIVES AND PAYLOADS For CHANG'E-7 MISSION

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Since the 1990s, China has been planning lunar exploration missions. From Chang'E CE-1 to CE-4 missions, China's lunar exploration program (CLEP) has successfully completed the mission goals of "orbiting" and "landing" of the lunar exploration project, showing the capability of reaching the Moon and landing on the lunar surface. The objectives of "orbiting" and "landing" are: (1) to gain a global and comprehensive understanding of the Moon through orbital spacecraft exploration; (2) to conduct exploration and surveying of the lunar surface with landers and rovers. The CE-5 mission is expected to be launched by the end of 2020, completing the mission target of "returning", i.e., collecting samples of lunar rocks and soils and bringing them to Earth.

In addition to CE-5 sample return mission, China has proposed a series of follow-up plans to explore the Moon [1]. With the south pole of the Moon as the main target, lunar *in situ* resource exploration and research will be carried out continuously through several missions,. The overall scientific objectives include (i) investigating the composition and structure of the Moon's interior; (ii) investigating the global distribution, content, and source of water and volatile components; (iii) measuring the age of the South Pole-Aitken (SPA) Basin; (iv) investigating the space environment above the lunar south pole. (v) *in situ* lunar resource utilization experiments; (vi) Moon-based observation and research of Earth; (vii) lunar orbit Very Long Baseline Interferometry system (VLBI) for astronomical research; (viii) scientific experiments related to the lunar surface ecosystem. On the basis of these objectives, CE-6, CE-7, and CE-8 missions are expected to be implemented. Through these three missions, China will have the ability to reach the full lunar surface and achieve the goals for *in situ* scientific research, resource exploration and application verification. Finally, a robotic scientific research station prototype will be built on the south pole of the Moon by 2035.

The CE-7 mission, scheduled for 2024, is the first mission in the follow-up missions (i.e., CE-6, CE-7, and CE-8) of CLEP. The scientific objective of the mission include: (i) obtaining the information of lunar inner ring structure, mineral and element components, the characteristic of the electric and magnetic fields, heat flow and gravitational field; (ii) obtaining the distribution and source of lunar water and volatiles, directly confirming the presence and source of water ice on the Moon; (iii) imaging the energetic neutral atoms with high space-time and energy resolution of the Earth's magnetails and understanding the dynamics of the earth's magnetails; (iv) researching the space environment such as lunar surface magnetic field, lunar dust and particle radiation, revealing the mechanism of solar wind causing the magnetic anomalies in the vortex region of the lunar surface [2].

The CE-7 probe, consisting of a relay satellite, an orbiter, a lander, a rover and a mini-flying probe, will be equipped with 23 scientific payloads. The total weight will be 8200kg, of which the weight of the scientific payloads is 415kg. By launching a relay satellite and an orbiter, CE-7 will establish a relay communication link from the lunar south polar region to the Earth, and will conduct a detailed survey of the environment and resources in the lunar polar region. *In situ* science and resource exploration of the lunar south pole will be completed through the lander, rover and mini-flying probe. The CE-7 probe will make breakthroughs in key technologies such as high-precision lunar detailed survey, fixed-point landing, shadow pit flying detection, and intelligent robots adapted to the harsh environment of the lunar polar region, and will achieve new developments in space technology [3].

The relay satellite supports relay communication and supports deep space VLBI measurement and radio observation research; The orbiter will carry the lander and the rover to complete earth-moon transfer and near-moon braking, release the relay satellite and the lander according to the flight procedures, and conduct high-precision detailed inspection of the Moon. The lander carrying the rover and the mini-flying probe, will make a soft landing on the south pole of the Moon to conduct scientific exploration of the lunar surface. After the lander lands safely, the rover will be transferred to lunar surface to carry out the *in situ* scientific explorations. The mini-flying probe, carrying a science payload named Water Molecule and Hydrogen Isotope Analyzer, takes off from outside the crater, lands in the permanently Shadowed area for a short period of time, goes around and lands in the light-filled area of the crater rim to perform motion detection [3].

In order to complete the above scientific mission objectives, CE-7 is equipped with 2 science payloads on the relay satellite, 5 science payloads on the orbiter, 7 science payloads on the lander, and 4 science payloads on the rover, and 1 science payload on the mini-flying probe [4]. The configuration relationships

of each science payloads and the scientific exploration missions are shown in table 1. Note that these scientific objectives and payloads proposed by Chinese scientists were not finalized yet and changes may be made before launching.

As CE-7 makes scientific explorations on the lunar south polar region, more mysteries will be revealed. China is open to cooperate with other countries on lunar exploration, and encourages the participation of planetary scientists from all over the world to establish a lunar science platform for communication [5].

Table1. The configuration relationships of each science payloads and the scientific exploration missions

Flight	Science payloads	Mission Objectives
Relay-satellite	Grid-based Energetic Neural Atom Imager	Obtain the global imaging data of neutral atoms in the earth's magnetosphere energy
	lunar orbit Very Long Baseline Interferometry system	Earth-Moon VLBI measurement and radio astronomy observation
Orbiter	High Resolution Stereo Mapping Camera	High precision topography of the lunar surface
	Miniature Synthetic Aperture Radar	High precision topography of lunar surface and permanent
	Wide Band Infrared Spectrum Mineral Imaging Analyzer	High precision mineral composition and surface thermal environment
	Lunar Neutron Gamma Spectrometer	High precision characteristic gamma ray and neutron flow data for lunar surface
	Lunar Orbit Magnetometer	Combined with a rover mometer to obtain lunar micromagnetosphere
Lander	Landing Camera	Landing area topography data
	Topography Camera	Landing area topography data
	In-situ Measuring System of Volatiles and Istopes on Lunar Surface	In situ exploration of volatiles in the landing area
	Lunar Soil Section Thermal Current Measuring	Measuring the lunar soil heat flow
	Lunar Surface Thermometer	Measure the temperature of lunar surface
	Extreme Ultraviolet Camera	Obtain the imaging data of the earth plasma layer
	Lunar Seismograph	Obtain the lunar seismic data on the south pole
Rover	Panoramic Camera	Obtain the topographic data on the rover area
	Rover Magnetometer	Obtain the magnetic field and its gradient change on the rover area
	Lunar Penetrating Radar	Obtain the data of shallow structure of lunar soil on the rover area
	Lunar Raman Spectrometer	Obtain the data of mineral composition on the rover area
Mini-Flying flight	Water Molecule and Hydrogen Isotope Analyzer	Water molecule and hydrogen isotope measurement on the lunar Permanently Shadowed area

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