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China's Planning for Deep Space Exploration and Lunar Exploration before 2030*

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Abstract The current lunar exploration has changed from a single scientific exploration to science and resource utilization. On the basis of the previous lunar exploration, Chinese scientists and technical experts have proposed an overall plan to preliminarily build a lunar research station on the lunar South Pole by several missions before 2035, exploring of the moon, as well as the use of lunar platforms and in-site utilization of resources. In addition, China will also explore Mars, asteroids and Jupiter and its moons. This paper briefly introduces the ideas of Chinese scientists and technical experts on the lunar and deep space exploration.

Key words Deep space exploration, Lunar exploration, Mars exploration

Classified index P 3

1 Deep Space Exploration Program of China before 2030

There will be four missions for the deep space exploration of China between 2020–2030, including two Mars exploration missions, one asteroid exploration mission, the Jupiter system (Jupiter and its moons) and interplanetary exploration mission beyond Jupiter. The details are given as follows.

1.1 The First Mars Exploration Mission

The first China's Mars exploration mission includes the orbiter, lander, and rover, which will be launched aboard a Changzheng-5 rocket in 2020. The global and overall Mars exploration will be carried out by the orbiter. High precision and spatial resolution in-situ measurement of the landing site will be conducted by the lander and rover, including space environment, topography, subsurface structure, and the atmosphere of Mars and so on. The spacecraft will be launched directly to the Earth-Mars transfer orbit from Wenchang, Hainan Province.

The scientific goals include: to characterize the global topography, geochemical composition, internal structure of Mars, and so on; to determine the soil characteristics and the water ice distribution on the Mars; to study the characteristics of atmospheric and ionospheric climates and environment of Mars.

1.2 Asteroid Exploration Mission

China's asteroid exploration is planned to conduct by 2030. The mission includes flyby observation, global remote sensing, landing and in-situ measurement and sample return.

The scientific goals include: to measure the physical features and detect the topography, surface composition, internal structure, space weathering, and water and organic matter, in order to obtain information on the formation and metamorphism of asteroids, and the origin and evolution of the early solar system; and to return samples from the target asteroid for high precision and spatial resolution in laboratories on Earth.

1.3 The Second Mars Exploration Mission: Mars Sample Return

The scientific goals of China's second Mars mission are mainly to obtain field geological information of the landing site *via* in-situ measurements and to select samples and return them to the Earth: to investigate the topography and the compositions of landing site *via* in-situ analysis; to analyze and study comprehensively the returned Martian samples in laboratories, including the soil structure, physical properties, and so on, in order to understand the origin and evolution of Mars.

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1.4 Jupiter System and Interplanetary Exploration Mission beyond Jupiter

China's Jupiter system exploration mission is orbital exploration, with the focus on Jupiter and its four largest moons to carry out large-scale remote-sensing observations.

1.4.1 Scientific Goals for the Jupiter System Exploration

The goals include: to study magnetic fields and plasmas of the Jupiter system and their interactions; to detect the variations of the composition and structure of Jupiter's atmosphere; and to detect the space environment, surface characteristics and internal structure of Galileo satellites (Callisto or Ganymede).

1.4.2 Scientific Goals of the Interplanetary Exploration Mission beyond Jupiter

The goals include: to study how the spatial and temporal variations of solar wind plasma and interplanetary magnetic fields of the Venus, Earth, Jupiter, and even Uranus; to study the evolution of the solar wind structure in the interplanetary space; and to study the interactions between solar wind and planetary magnetospheres.

2 Lunar Exploration Program of China before 2030

2.1 Introduction of China's Previous Lunar Exploration Programs

The China's Lunar Exploration Program (CLEP) is divided into three phases named by "orbiting around the Moon", "landing on the Moon" and "returning from the Moon" before 2020. Up to now, Chang'E-1, Chang'E-2, and Chang'E-3 have been successfully launched.

The Chang'E-4 probe will be launched in 2018, which includes a telecommunication relay satellite, a lander, and a rover, which will land at the Aitken basin on the far side of the Moon for the first time.

The Chang'E-5 probe is going to be launched in 2019. The primary scientific objective is to collect lunar soil and rock samples and return them to the Earth for subsequent analysis.

2.2 China's Lunar Exploration Program before 2030

After more than three years of discussion, Chinese scientists and technical experts have proposed an overall plan to build a preliminary research station on the Moon's South Pole through implementing 3∼4 missions during the period of 2020–2030. The details are given as follows.

(1) The first mission includes a telecommunication relay, an orbiter, a lander, a rover and a flying detector. The primary scientific objectives are: to determine the topography, distribution, and composition of minerals surrounding the landing site; to explore the space environment on the lunar surface; to detect water ice in the permanently shadowed area; and to observe the Earth and build the Earth-Lunar VLBI system around the orbit of the Moon.

(2) The second mission is the backup of Chang'E-5. The primary scientific objectives are: to investigate the topography, composition and subsurface structure of the landing site and the sample collection area; and to collect the samples at the Lunar South Pole and return them to the Earth for analysis in the future.

(3) The third mission includes a lander, a rover, and a flying detector. The primary scientific objectives are: to carry out in-situ resource utilization experiments and lunar terrestrial small ecosystem; to carry out a moon-based observation on the Earth, including measuring Earth's energy imbalance and plasmasphere and magnetosheath; and to investigate the topography, composition, and substructure of the landing site.

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