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Preliminary Scientific Exploration Programs for Mars Surface Composition Detection Package of China's First Mars Exploration

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Abstract

LIBS technique has been widely used in recent deep space explore missions to identify planetary material because of its advantage in requiring no sample pre-treatment, non-contact measurement and simultaneously rapid multi-element analysis. It will be adopted by Mars surface composition detection Package(MarsCoDe) on-board the rover of China's first Mars exploration mission(HX-1) in 2020. This article introduces the scientific exploration programs of MarsCoDe.

1. Background

LIBS technique was first used by ChemCam on-board Curiosity launched on 2011 to detect Mars surface element composition[1,2]. ESA ExoMars equipped a Raman spectrometer to identify surface elements of Mars on March 2016. Although the mission failed, it will continue to perform the second exploration in 2020. LIBS technique will also be adopted by Mars surface composition detection Package on-board the rover of China's first Mars exploration mission in 2020. The rover of Mars 2020 mission will be equipped with a SuperCam which combines the LIBS and Rama techques to detect the surface element of Mars[3,4,5]. So, in 2020, ESA ExoMars 2020, China First Mars Mission and NASA Mars 2020 will be launched together. LIBS technique will be used in all these missions. LIBS data will be used for 1)Information on elemental composition of Mars surface helps get insight into geological evolution history of Mars and 2)Quantitative determination of element (e.g. C,H,P,O,S) provides evidence for life on the Mars surface.

2. MarsCoDe

China first Mars exploration mission (HX-1) plans to launch to Mars in 2020, with an orbiter and a landing rover . The mission will collect a tremendous amount of data with its various onboard payloads for the global exploration by orbiter, and high precision detection in regional area by rover

The Mars Surface Composition Detection Package (MarsCoDe) is one payload onboard the rover of China's first Mars exploration mission. The scientific objectives of MarsCoDe is to perform Laser-induced spectrum observation of Mars surface materials in a distance between 1m and 7m, and obtain the emission lines of plasma between 240nm and 850 nm at high spectral resolution. It also can obtain high resolution reflectance spectra between 850nm and 2400nm. At lease ten elements of Mars surface materials will be expected to analysis. Its primary scientific goal is: 1)Determination of element composition of Mars surface materials; 2)Identification and classification of Mars surface mineral and rock.

MarsCoDe includes six modules: 1)The laser can ablate the target and generate a plasma and also measure the distance between the target and instrument. The distance will be used for data processing. 2)It has two spectra detection modules(one is LIBS spectra detection module(240nm~850 nm), another is SWIR spectra detection module(850nm~2400nm)). 3)A micro-imaging camera can obtain high spatial resolution image for targets. At a distance of 3m, its spatial resolution is about 0.3mm/pixel. 4)A two-dimensional pointing mirror can be pitching and yawing movement. So the laser beam can accurately point to the target. 5)Calibration target will be used for onboard calibration. The calibration target have 12 cylindrical disks, used for LISB spectra calibration and SWIR spectra calibration.

3. Scientific Exploration Programs

Topography camera, multi-spectral camera and micro-imaging camera are three cameras on HX-1 rover. Their spatial resolution are similar at distance between 1m to 7m. According to reduce downloading data, we plan to only use topography camera images for MarsCoDe target selecting. Topography camera have two cameras, we can get stereo image for mars surface and calculate three-dimensional coordinates and distance for selected target. So the laser beam can accurately point to the target.

Three Scientific Exploration Model are designed for MarsCoDe working on mars. 1)Single-point detection, including: One time laser ablating, 50 times LIBS plasma spectra collecting(first five spectra are abandoned, latter 45 spectra are averaged); One time SWIR reflectance spectra collecting; One microscopic Image taking after spectra detection. 2) Depth profile detection, including: 200 times laser ablating at the same location, Cumulative breakdown is expected to be 10um to 500um; For each time, LIBS plasma and SWIR reflectance spectra are same as single-point detection; Two microscopic images taking after first time and last time respectively. 3)Scanning detection: in order to study horizontal variation of element composition and layered structure of martian rocks. Including two ways scanning：1) 5 to 20 points of line scanning; 2) 2 × 2 or 3 × 3 matrix.

Before HX-1 rover is separated from the landing platform, topography camera will be used to obtain stereo images around the landing site, and a mosaic image and terrain data results will be generated. And a preliminary scientific exploration path and detection point distribution will be planned out. The rover mission cycle is about 90 martian days. Every 3 Martian days are a cycle of Scientific exploration.During each exploration cycle, when the rover arrives at one scientific point. Firstly, topography camera will be used to obtain stereo images in the front of the rover. A background topography data will be generated from these images. Several scientific exploration target will be selected by scientists. Then, LIBS plasma spectra , SWIR reflectance spectra and microscopic Image will be obtain for each target. In order to obtain the background rock type around the detection targets, multispectral images(including eight visible-near infrared spectra) may be obtained by multispectral camera.

4. Summary

LIBS technique has been widely used in recent deep space explore missions. In 2020, ESA ExoMars 2020, China First Mars Mission and NASA Mars 2020 will be launched together. LIBS technique will be used in all these missions. And it will be used to determine elemental composition and provide evidence for life on the Mars surface. MarsCoDe is one payload onboard the rover of China's first Mars exploration mission(HX-1). It has two spectra detection modules, one for LIBS spectra detection (240nm~850 nm), another for SWIR spectra detection (850nm~2400nm). Three Scientific Exploration Model of MarsCoDe will be used during the rover mission cycle. Its exploration data will be used for 1)Determination of element composition of Mars surface materials; 2)Identification and classification of Mars surface mineral and rock.

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