Paper ID: 71486
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29th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Space Science Missions (2)

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MISSION DESIGN OF 12U CUBESAT FOR EXPLORATION DETECTION AND CHARACTERIZATION BASED ON NULLING INTERFEROMETRY

Abstract

The observation of exoplanets, since 1995, deepens understanding of planetary formation path and cosmic evolution. The exploration of planetary characterization in the habitable zone of sun-like stars, especially for livability and biosignature, is one of the core problems of exoplanetary science. Transit spectroscopy and direct detection are two main techniques for composition analysis, while only some exoplanets with the phenomenon of transit could be described by transit spectroscopy. On the contrary, the application of direct methods is more meaningful, but it has two problems. One is the high illumination contrast between the target exoplanet and the star and the other is insufficient angular resolution. Nulling interferometry effectively reduces the luminous flux of stars and the angular resolution can be improved by the expansion of pupil aperture, hole spacing, and baseline length. These techniques are easier to implement on large space telescopes. However, compared with using small satellite platforms, large satellite missions based on nulling interferometry method for exoplanet characterization would need much more resources and funding support.

In this paper, a 12U CubeSat mission was designed by the cooperation of Dalian University of Technology, Centre Spatial de Liege, TU Delft, Innovation Academy for Microsatellites of Chinese Academy of Science is proposed for the exoplanet research. The main objectives are to analyze the physical property, habitability, and search biosignature for the exoplanet Proxima b, which is closest to the solar system. The payload of the mission is nulling interferometer including two telescopes (or aperture collectors) feeding optical fibers, transmits light to a beam combiner placed at the center of the payload, which effectively counteracts the constant straylight by generating a 180-degree phase shift. The science platform is a 12U CubeSat. To extend the baseline length and improve the angular resolution, the CubeSat adopts the deformable structure. After deployment from the launcher, the CubeSat would transform from a Cube into a straight-line configuration. A high-precision integrated attitude determination and control system together with a micro-electric propulsion system would be developed, which could achieve attitude determination accuracy better than 3 arcseconds and control accuracy better than 0.003 degrees. Now, the mission has been funded by the Ministry of Science and Technology of the People's Republic of China.

The international teams are now working together on the project. This project would be the forerunner for the direct detection of exoplanet research.