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EVALUATION AND MITIGATION OF REACTION WHEEL DISTURBANCES IN A MICRO-SATELLITE FORMATION FLYING INFRARED INTERFEROMETER MISSION

Abstract

The microvibration induced by spacecraft's components, such as reaction wheels, can affect the pointing accuracy of onboard mission instruments. While disturbance evaluation and management based on actual measurements have been extensively studied for large satellites, similar research on nano- and micro-satellites (approximately 100 kg or less) remains limited. However, in recent years, the demand for strict pointing accuracy in micro-satellites has been increasing, particularly in fields such as formation flying, optical communications, and Earth observation, where addressing disturbances has become essential.

SEIRIOS is one such micro-satellite mission designed to demonstrate the concept of a space infrared interferometer. The interferometer consists of one 50 kg-class micro-satellite and two 6U CubeSats, and it is planned to be launched into low Earth orbit and arranged in a linear formation. The micro-satellite is positioned between the two CubeSats, which maintain a constant distance of 10 to 100 meters from the micro-satellite. The CubeSats reflect starlight toward the micro-satellite, where the light is collected by the densified pupil spectroscopy interferometer. This mission aims to demonstrate a stellar interferometer in space as well as to serve as a low-cost technology demonstration for future high-precision, large-scale formation flying missions.

To construct a stellar interferometer, relative position control is typically required with an accuracy of approximately 1/10th of the observation wavelength. In this mission, the control accuracy requirement during the 10ms exposure time is $0.5\mu m$—a level at which disturbances become a significant concern. Excessive disturbances could lead to blurring of the interference fringes, degrading fringe quality. Ad-

ditionally, reducing disturbances allows for longer exposure times, which is critical for observing fainter celestial objects. Thus, suppressing disturbances is not only crucial for mission success but also contributes to expanding the range of observable targets.

In this study, based on the measured data of reaction wheel microvibration obtained through experiments, we estimated the impact of disturbances on the quality of interference fringes and image reconstruction in SEIRIOS mission with numerical simulations. Furthermore, we investigated methods to suppress these disturbances to enable longer exposure times. Our findings contribute to the understanding of disturbance management in micro-satellites and high-precision formation flying missions.