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NUMERICAL EVALUATION OF ON-ORBIT ATTITUDE BEHAVIOR FOR MICROSATELLITES WITH VARIABLE SHAPE FUNCTION

Abstract

The objective of this study is to develop a strategy for high attitude stability and agility in satellites and evaluate the feasibility through numerical simulations. It is usually difficult to cope with both agility and stability in attitude control.

The strategy will play a great role in the progress of microsatellites because microsatellites with higher performance are required for advanced missions in recent years. One example of such mission requiring high attitude performance is the astronomical observation of gravitational wave sources by a microsatellite. In February 2016, the first gravitational wave in the human history was detected by LIGO. The Fermi observatory had also detected a gamma-ray flash coincident with the gravitational wave. If that is true, the BH merger must erupt something in space. To investigate the nature of this kind of phenomena, survey observation of the X-ray or optical counterparts are essential and such challenging and urgent missions should be achieved by microsatellite. Gamma-ray emission lasts only few hundred of milliseconds and therefore, agile attitude maneuvering is required to start pointing observation quickly. At the same time the attitude stability is also important to achieve deep observation. Both the stability and the agility are key to perform the mission.

In our previous studies, we proposed a novel attitude control method called variable shape attitude control (VSAC). VSAC is a method for attitude control using anti-torque generated by driving appendages such as the solar array paddles. We call such a function for driving appendages “variable shape function”. The authors have revealed that VSAC allowed a satellite to be able to maneuver rapidly whilst maintaining high attitude stability against disturbances as well. However, performance evaluations with numerical consideration of on-orbit disturbance and practical errors of hardware has not been conducted yet.

This paper includes the following contents. First, the advantages of VSAC is verified compared to a conventional actuator such as reaction wheels. In the next step, we analyze the sensitivity of attitude motion to designed parameters to reveal the performance of the satellite by considering structural vibration. Finally, selecting actuators and sensors and considering their measurement error, driving error and on-orbit disturbance torque, we conduct integrated simulations to discuss the performance of the proposed strategy. These simulations also reveal the feasibility of the astronomical observation mission mentioned above.