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REQUIRED TECHNOLOGIES FOR A MISSION OF A GAMMA RAY OBSERVATION BY FORMATION FLYING SPACECRAFT IN SEL2 HALO ORBIT: FF-LAGRAN

Abstract

Observation of MeV (Mega electron Volt) gamma rays in the universe are important to investigate various universe phenomena including the phenomenon how and where neutron-rich matter is produced. However, Observation of cosmic rays from the ground is generally difficult due to air disturbance and cosmic ray absorption. Additionally, the MeV gamma rays are quite difficult to observe due to the Compton scattering phenomenon. Comparing the sky map of the GeV and TeV regions of gamma rays, the amount of MeV gamma ray observation is quite small, and the sensitivity and angular resolution of MeV gamma rays are significantly inferior. In fact, MeV gamma ray observation has been conducted by two spacecraft (CGRO and INTEGRAL) so far (Schonfelder, V. 1993, and Winkler 2003), limited to the regular observation from the specific Galactic plane and the observation of the gamma rays from the Galactic center and from the supernova named SN2014j.

In order to improve the sensitivity of the MeV gamma rays, we proposed FF-LAGRAN (Formation Flying Liquid Argon gamma ray AstroNuclear telescope) mission which aims to achieve a spatial resolution 100 times better than the other space missions mentioned above. FF-LAGRAN comprises two spacecraft inserted into the SEL2 (the second Sun-Earth Lagrange point) halo orbit: the parent spacecraft with a Compton camera with liquid argon, and the child spacecraft equipped with an encoded aperture mask. Liquid argon inside the Compton camera itself is a detector, and its utilization enables to achieve the high sensitivity detection. The realization of the high angular resolution requires to control child spacecraft on the line-of-sight direction of the parent spacecraft precisely; therefore a high precision relative attitude and position control system is necessary to achieve this mission.

The FF-LAGRAN mission requires the following technologies: an optimal orbit design for formation flying satellites in the SEL2 halo orbit; a method to determine and control the relative position and attitude of the satellites with high precision; and a thermal control method for the Compton camera.

This paper discusses the orbit control methods to point in a specific direction to observe celestial objects with persistent emission and transient astronomical phenomena. This paper also explains the relative position and attitude determination method using Coded Laser System and Quadrant Photodiode Sensor System. Finally, this paper mentions the cryogenic thermal control system to maintain the temperature inside the Compton camera between 80 K to 84 K in order to keep argon liquid.