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Development of JUICE/Ganymede Laser Altimeter (GALA)

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”Is there a life elsewhere in the universe?” It is a fundamental question deeply rooted on intelligence of human beings. And a clue of this question may be found on Ganymede. After magnificent achievements of Galileo and Voyager missions, an existence of thick liquid water layer, namely subsurface oceans under icy crust, has been implied for three icy satellites of Jupiter, Ganymede, Europa, and Callisto. And water in liquid state is thought to be a necessary condition for emergence of life in the field of astrobiology. The evidence of ocean, however, is not widely accepted, because it depends on an inferences of electromagnetic observation and surface morphology. Looking for new evidences and clues for these important issues, a new mission to Jupiter system is planned by European Space Agency. It is the Jupiter Icy Moon Explorer (JUICE). JUICE will be launched in 2022, and will arrive at Jupiter in 2030. After several fly-bys to Europa and Callisto, JUICE will be inserted into an orbit around Ganymede in 2032 and will continue scientific observations for eight months until the end of nominal mission in 2033.

Ganymede Laser Altimeter, GALA, is one of model payloads and measures distance between the spacecraft and the surface of the satellite from time of flight of laser pulse. By taking positions of the spacecraft and mass center of the satellite, surface topography of the satellite is calculated from measured distances. The GALA data are particularly important for finding of internal ocean. First, if the ocean exists beneath icy crust, tidal deformation of the satellite is so large that temporal variation of the topography as great as several meters is expected. Second, small eccentricity of orbit of Ganymede causes libration that will be observed as lateral shifts of footprint of laser beam at the surface. And third, improved determination of spacecraft orbits by cross over analysis results in precise estimate of low degree harmonics of gravity field. Thus accurate Love number will be calculated to infer internal density structure of the satellite.

Global topographic data derived by GALA are also important for the study of tectonic history at the surface, elastic and viscous structure of ice crust, and thermal evolution of interior of the icy satellite. For example, linear structures such as ridges and grabens reveal extension stresses due to past variation of thermal states. As well, flat surface and thin crust may indicate partial melting of the crust and consequent subsurface lake. These observations on various geologic activities lead to new understanding of transport of heat and materials from inside to the surface of the satellite. Further, a comparison of styles of tectonics of ice crust and that of silicate lithosphere will likely shed a new light on theory of plate tectonics of the Earth.

GALA is developed by international collaboration of scientists and engineers in Germany, Switzerland, Spain, and Japan. The conceptual design is based on the laser altimeter on board of BepiColombo consisting of transceiver unit (TRU) with laser optics and appropriate electronics, electronic unit (ELU) with digital range finder module, digital processing module and power converter module, and laser electronic unit (LEU) with laser control electronics. Japanese team takes receiver telescope, its back-end optics, detector, and analogue electronics of TRU. The transmission optics of TRU and LEU are developed at DLR in Germany, and ELU is developed at Bern University in Switzerland. Assembly and integration are conducted at DLR.

The initial designs of analogue electronics and receiver telescope including back-end optics have been examined. A main mirror of the telescope will be 300 mm in diameter and be made of aluminum with gold coat. The same detector as those of BELA, Hayabusa, and Kaguya will be taken. Structural and thermal analyses are currently undertaken.

Keywords: Ganymede, Icy satellite, Planetary exploration, Laser altimeter