An Overview of the First Japanese Formation Flight Mission Using Compact Satellites for In-Situ Observations of the Space-Earth Coupling Mechanisms

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We summarize the recent progress and latest status of our formation flight mission for the integrated in-situ observations using compact satellites in a polar orbit at altitudes of about 300-4000 km, particularly on the technical investigations and the possibilities of substantial international collaborations. The most important science target in this mission is the demonstrative and quantitative investigation concerning the physical processes and mechanisms controlling the space-Earth connections. In the case of our planet, Earth, the magnetosphere-ionosphere-thermosphere couplings are the observational objectives on the basis of the direct and simultaneous measurements at multipoints using 2-4 compact or micro satellites designated for the advanced space explorations. We tentatively call this mission FF-MIT (Formation Flight exploration for Magnetosphere-Ionosphere-Thermosphere coupling mechanisms). The detailed mission targets and the state-of-the-art methodology will be given in this presentation. The key issues of this FF-MIT could be listed as follows: Transports and conversions of plasma and electromagnetic energies across the space-Earth boundaries, Planetary/space plasma accelerations and mass escape via the wave-particle interactions, Response of the neutral atmosphere to space plasma activities via the plasma-neutral interactions.

Because we have been carrying out the novel types of the observations with the previous polar orbiting satellite, Reimei, and several sounding rockets called SS-520, it is quite realistic and appropriate that we make a convincing and promising proposal for more advanced future mission. Our team also has the best experience and heritage in Japan of the space plasma measurements owing to our essential participations and contributions in previous and on-going missions, for instance, Geotail, Kaguya, BepiColombo-MMO, ERG(Arase), and MMS. In particular, the challenging technique for the wave-particle interaction analyses developed for the Arase satellite mission would be applied also in the FF-MIT mission for quantitative estimates of the energy transports in the transversal ion accelerations and Alfvenic electron accelerations parallel to the local magnetic field occuring in the polar ionosphere.

Since September of 2016, we have been addressing several technical and engineering subjects through the discussions and investigations with the engineering groups in JAXA and the design/fabrication teams in manufacturers. The satellite configuration/specification and the cluster launch capability with the Epsilon rocket of JAXA should be clarified and fixed before the working group establishment and the mission proposal submission. It is also plausible to consider some international collaborations regarding the satellite provision and the instrumental contributions in order to strengthen the scientific objectives and simply increase the possibily of simultaneous multi-point observations. From this viewpoint, we have already started the face-to-face discussions with some overseas research groups.

In addition to this FF-MIT space exploration using the formation flight technique, it is also essential to coordinate and perform simultaneous observations with progressing ground-based observational facilities/equipments like EISCAT_3D, high-speed optical imagers using EMCCD in order to obtain the physical parameters especially in the wider dimensions/areas of the upper atmosphere. The specialized science center would be required for effectively coodinating these integrated observations in space and on the ground and significantly organize and expand the data analyses/modeling/simulation activities,

which are very similar to the situation of the successfully on-going Arase project owing to our vast efforts. We are planning to propose the FF-MIT mission toward the realization of the fascinating demonstrative research based on this cutting-edge space exploration mission and the powerful ground-based sites in mid 2020s.

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