Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG31-18 Room:202 Time:May 28 16:30-16:45

Space-terrestrial couplings and polar ionosphere/thermosphere dynamics studied by formation flight of compact satellites

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We have been discussing a possibility and feasibility of the future space exploration mission for studying the space-terrestrial couplings based on the space plasma dynamics. In this future mission, we are planning to elucidate the universal particle acceleration/heating and transport mechanisms by using the in-situ and remote-sensing observation techniques with a formation flight of multiple compact satellites. These plasma dynamics are caused mainly by the terrestrial ionosphere-magnetosphere coupling processes and also affect both mangetospheric plasma dynamics and upper atmospheric (ionospheric and thermospheric) phenomena in the Earth's polar regions. In past, our Reimei satellite, the first Japanese microsatellite focusing on the exploration of the fine-scale auroral dynamics, was launched in August, 2005. Reimei successfully obtained the in-situ observational data for the space plasmas but the imaging camera data for the auroras, the airglows, and the sprites. These Reimei results have been leading to several new satellite mission proposals in the world. We are now organizing a highly plausible mission based on our own experimental experiences obtained from Reimei and our data analysis achievements, for instance, in the ISAS Akebono mission and the NASA FAST mission. It is undoubtedly evident that highly accurate measurements of magnetic/electric fields and plasma waves should be realized in this future satellite missions in addition to the monochromatic auroral imaging camera with high-time/spatial resolutions and the energetic and suprathermal electron/ion analyzers with a high-time resolution. Thermal plasma instruments are also important for measuring the plasma circumstances. It should be noticed that the neutral particle instruments, which are now under development and modification in Japan, would significantly contribute to the quantitative researches of the polar ionospheric and thermospheric dynamics. Toward the realization of the new space exploration mission, we are making intensive efforts for defining the scientific mission strategy and the specifications of the science instruments. In the future mission planning, we are now considering the following features. 1: Changeable formation flight with multiple compact satellites, whose weights are roughly 100 kg, is essential for simultaneous multipoint observations of fine-scale auroral phenomena. 2: The precise three axial attitude control system should be applied for realizing the high-quality 2-D imaging of auroral emissions and the simultaneous measurements of the pitch-angle distributions of the auroral particles with top-hat type energy analyzers. 3: It is crucial to capture the ram direction of the satellite with the attitude control in order to measure the shifted velocity distributions of the core ions. 4: The electric/magnetic field instruments and the plasma wave instruments should be installed on the satellites for the integrated observations. Particularly, it is one of the most prominent features of this mission to perform wave-particle interaction analyses based on these comprehensive and integrated measurements of the plasma particles and waves, and the fields. 5: Neutral particle instruments for the velocity distribution measurements would make essential contributions from the farsighted viewpoint in the upper atmospheric dynamics beyond the space plasma regimes. 6: The sun-synchronous orbit at relatively low altitudes would be desirable both for bringing the observational advantages. In this presentation, we introduce the multi-sided scientific importance and several types of our exploration mission specification.

Keywords: space plasma, particle acceleration, space-terrestrial coupling, wave-particle interaction, integrated observation, formation flight