Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

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The Japanese space physics community is now conducting the FACTORS mission, which is the first space exploration mission using a formation flight configuration based on multiple satellites orbiting in the terrestrial polar magnetosphere-ionosphere-thermosphere coupling regions. It is well understood that the in-situ observations integrating the particle, field, wave measurements could bring us with unique opportunities for elucidating the dynamics of the space plasmas and the terrestrial/planetary upper atmospheres. Also in the FACTORS mission as the next community-leading mission after the ERG(Arase) satellite mission, we are planning to realize more advanced integrated measurement system than the ERG(Arase) as well as the unified research framework based on the satellite/ground-based observations and the data analysis/modeling/simulation approaches. One of the science objectives in FACTORS is the demonstrative and quantitative verification on the energy transport mechanisms emerging in the ionospheric ion accelerations in the perpendicular direction to local magnetic fields, which have been frequently observed as transversely accelerated ions(TAIs) by previous/ongoing satellites and sounding rockets at altitudes of several hundreds to a few tens of thousands of km in the terrestrial auroral regions. This type of ion accelerations is quite important not only in our understanding the elemental physical mechanisms in the space plasmas but also in the estimate of the amount of the outflowing/escaping terrestrial plasmas. Although it is definitely evident that the plasma waves excited/propagating in the ionosphere are the exclusive energy source for TAIs according to the statistical analyses of the observational results, it should be noted with a surprise that we have not reached any consensus which mode of plasma waves is dominantly or more effective in the ion accelerations. It should also be noticed that the plasma wave modes responsible for TAIs could change, dependent on the event regions, the ambient ionospheric conditions, and the energy ranges of the accelerated ions, which means the there are some observational difficulties especially in the case of single satellite mission because the observational information obtained by in-situ measurements with a single satellite are too much limited to separate time variations from spatial distributions. In the FACTORS mission, it is required to overcome these observational problems by applying the controllable flight formation and attitude configurations of multiple satellites with an adequate accuracy and additionally developing the innovative observational techniques in the ion and wave measurements. In order to identify the plasma wave modes responsible for TAIs, we utilize several types of advanced formation flight configurations of the multiple satellites for longer plasma waves. As the observational technique for shorter waves, an interferometry method using single electric field probes on each satellite would be applicable. In the ion measurements, it would be essential to develop and install two types of ion energy-mass spectrometers covering from the supra thermal to the low-energy ranges independently with wide and controllable field-of-views and adequate energy/angular resolutions to capture the core ion components by compensating the convective plasma drift motion in the auroral regions or trace the conical pitch-angle distributions of the accelerated and

upwelling ions. It could also be a breakthrough to carry a gyrophase-resolving ion energy-mass spectrometer with the similar specification to the low-energy ion spectrometer. This presentation introduces the observational methodology and techniques with which we could demonstratively and quantitatively address the ionospheric ions accelerations from the viewpoint of wave-particle interaction mechanisms occurring universally in space.

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