Software-type Wave-Particle Interaction Analyzer on board the ARASE satellite

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The Wave-particle interaction analyzer (WPIA) is a new method of observing wave-particle interactions in space. Based on the cutting-edge of technologies in the onboard instruments, the Software-type WPIA (S-WPIA) is installed in the ARASE satellite, which was successfully launched on December 20, 2016. The present paper introduces the principles of the WPIA and describes the detailed design of the S-WPIA on board the ARASE satellite. Understanding wave-particle interactions is essential in the study on space plasma environments, because space plasmas are collisionless and their kinetic energies are transferred through wave-particle interactions. In the conventional way of the study on wave-particle interactions via satellites, we have compared features of plasma waves with velocity distribution functions. However, that conventional way is not appropriate for identifying wave-particle interactions quantitatively. The nature of wave-particle interactions lies in the phase difference between electric field vectors($\boldsymbol{E}$) and velocity vectors of particles($\boldsymbol{V}$). This appears as the inner product form as $\boldsymbol{E} \cdot \boldsymbol{V}$. The conventional way using velocity distribution functions misses the information of this phase difference, because the velocity distribution function is obtained on the time integration basis. The WPIA overcomes the above problem in the conventional method by handling each detected particle and instant electric field intensity with keeping the enough accuracy in the relative time difference between them. The ARASE satellite and its onboard S-WPIA instrument should be frontiers in the study of wave-particle interactions. The leading edge of the system in the ARASE satellite allows us to collect whole information of particles at every particle detection timing and instant electric fields at every sampling timing. The collected particle and waveform data are stored on the onboard data storage called Mission Data Recorder (MDR). The S-WPIA calculates the phase difference and other quantities onboard reading out the data from the MDR and send the results as well as raw data of particles and plasma waves to the ground.
The main objective of the S-WPIA on board the ARASE satellite is to detect quantitatively the wave-particle interaction related to the generation of the Chorus emissions. The SWPIA also targets the quantitative detection of accelerations of electrons due to plasma waves. The function of the S-WPIA has been already confirmed during the initial operation of the ARASE satellite. The present paper introduces the details of the S-WPIA and discuss the strategy how we meet the objective of the S-WPIA in the operation.

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