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Significance of Wave-Particle Interaction Analyzer for direct measurement of nonlinear wave-particle interactions

Yuto Katoh (1), Hirotsugu Kojima (2), Yoshiharu Omura (2), Satoshi Kasahara (3), Masafumi Hirahara (4), Yoshizumi Miyoshi (4), Kanako Seki (4), Kazushi Asamura (3), Takeshi Takashima (3), and Takayuki Ono (1)

(1) Graduate School of Science, Tohoku University, Japan (yuto@stpp.gp.tohoku.ac.jp), (2) RISH, Kyoto University, Japan, (3) ISAS/JAXA, (4) STEL, Nagoya University, Japan

In the upcoming ERG satellite mission, Wave-Particle Interaction Analyzer (WPIA) will be installed as an on-board software function. We study the statistical significance of the WPIA for measurement of the energy transfer process between energetic electrons and whistler-mode chorus emissions in the Earth's inner magnetosphere. The WPIA measures a relative phase angle between the wave vector and velocity vector of each particle and computes their inner product $W(t)$ (= $qE \cdot v$), while $W(t)$ is equivalent to the variation of the kinetic energy of energetic electrons interacting with plasma waves. We evaluate feasibility of the WPIA by applying the WPIA analysis to the simulation results of whistler-mode chorus generation. We compute $W(t)$ of a wave electric field vector observed at a fixed point assumed in the simulation system and a velocity vector of each energetic electron passing through this point. By integrating $W(t)$ in time, we obtain significant values of $W_{\rm int}$ in the kinetic energy and pitch angle ranges as expected from the evolution of chorus emissions in the simulation result. The statistical significance of the obtained $W_{\rm int}$ is evaluated by calculating the standard deviation σ_W of $W_{\rm int}$. In the results of the analysis, positive or negative $W_{\rm int}$ is obtained at the different regions of velocity phase space, while at the specific regions the obtained $W_{\rm int}$ values are significantly greater than σ_W, indicating efficient wave-particle interactions. The present study demonstrates the feasibility of using the WPIA as direct measurement of wave-particle interactions.