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Science objectives and implementation of Software-type Wave-Particle Interaction Analyzer (SWPIA) by RPWI for JUICE

KATOH, Yuto[1*] ; KOJIMA, Hirotsugu[2] ; ASAMURA, Kazushi[3] ; KASABA, Yasumasa[1] ; TSUCHIYA, Fuminori[1] ; KASAHARA, Yoshiya[4] ; IMACHI, Tomohiko[4] ; MISAWA, Hiroaki[1] ; KUMAMOTO, Atsushi[1] ; YAGITANI, Satoshi[4] ; ISHISAKA, Keigo[5] ; KIMURA, Tomoki[3] ; MIYOSHI, Yoshizumi[6] ; RPWI-JAPAN, Team[1]

[1]Graduate School of Science, Tohoku University, [2]Research Institute for Sustainable Humanosphere, Kyoto University, [3]ISAS/JAXA, [4]Univ. Kanazawa, [5]Toyama Pref. Univ., [6]STEL, Nagoya Univ.

We present science objectives of Software-type Wave-Particle Interaction Analyzer (SWPIA), which will be realized as a software function of Langmuir probes (LP) running on the DPU of RPWI (Radio and Plasma Waves Investigation; PI: J.-E. Wahlund, IRF-Uppsala, Sweden) for the ESA JUICE mission. SWPIA conducts onboard computations of physical quantities indicating the energy exchange between plasma waves and energetic ions. SWPIA cannot be achieved without onboard inter-instruments communications, which will be realized by efforts of RPWI, PEP (Particle Environment Package; PI: Stas Barabash, IR-Kiruna, Sweden) and J-MAG (JUICE Magnetometer; PI: M. Dougherty, ICL, UK). By providing the direct evidence of ion energization processes by plasma waves around Jovian satellites, SWPIA contributes scientific output of JUICE as much as possible with keeping its impact on the telemetry data size to a minimum.

SWPIA measures the energy transfer process between energetic particles and electromagnetic plasma waves [Fukuhara et al., EPS 2009; Katoh et al., AnGeo 2013]. SWPIA will be firstly realized in the ERG satellite mission in the Earth's inner magnetosphere to measure interactions between energetic electrons and whistler-mode chorus. We will apply SWPIA to ion-scale wave-particle interactions occurring in the Jovian magnetosphere. SWPIA clarifies where/when/how heavy ions are energized by waves in the region close to Ganymede and other Jovian satellites. In SWPIA of RPWI for JUICE, we focus on the interactions between energetic ions (a few to tens of keV) and ion cyclotron waves (typically less than 1 Hz). SWPIA uses wave electromagnetic field and ion velocity vectors provided by RPWI sensors and PEP, respectively, with referring three-components of the background magnetic field detected by J-MAG. SWPIA measures a relative phase angle between the velocity vector v_i of i-th particle of charge q_i and the wave electric field vector at the timing of particle's detection ($E(t_i)$) and computes an inner product of $W(t_i) = q_i E(t_i) \cdot v_i$, where $W(t_i)$ corresponds to the variation of the kinetic energy of the i-th energetic particle. We accumulate W for detected particles to obtain $W_{int} = \sum_i W(t_i)$, and we expect statistically significant values of W_{int} for the case of the measurement at the site of efficient wave-particle interactions. In this presentation, we discuss details of the implementation of SWPIA of RPWI and inter-instruments communications among RPWI-PEP-J-MAG of JUICE.

Keywords: Jovian magnetosphere, Jovian satellite, wave-particle interactions