Modeling Electric Potential Produced by Photoelectrons and Spacecraft charging: A case of the Arase satellite

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Measurement of electric fields is a key to understand the magnetospheric dynamics as a response to solar wind. For this objective, double probe technique with long wire antennas extending from a spinning spacecraft has been employed. It is more difficult in a tenuous magnetospheric plasma due to a long Debye shielding distance, dominance of photoemission in current balance of the probes, positive charging of spacecraft body, unstable electric potential of the spacecraft, and so on. In usual, a bias current is fed to the probes to reduce resistance of the probes to the ambient plasma and stabilize the probe potential.

For the Arase satellite case, the Wire Probe Antenna (WPT) connected to Electric Field Detector (EFD) of the Plasma Wave Experiment (PWE) has the role for this objective. The WPT is two pairs of double probes comprising 60-mm-diameter spheres on tips of 15-m wire antennas. Although the antenna length is limited by the cost reason, Arase is tried to minimize the effect of asymmetric emission of photoelectrons from the spacecraft body by setting its spin axis within 15 degrees from the sun direction [1,2]. Nevertheless, in a tenuous plasma, the measurement suffers from an apparent sunward electric field with a strange, non-sinusoidal waveform of potential difference between the probe and the spacecraft. We identified that the effect of the spinning was still evident even with this design.

For this objective, we investigated to model the photoelectron cloud and the spacecraft charging with a single negative charge outside the spacecraft and a positive charge on the body of the spacecraft, respectively. They are displaced toward the sun from the center of the spin of the wire antennas. Even with the small angle variations to the Sun, the illuminated cross-section of the spacecraft is slightly changed, and the distance of a probe from each electric charge varies depending on the spin phase. It causes the separation of positive and negative charges and produces non-sinusoidal waveform of electric potential at the probe. We can find the best-fit position of the negative charge representing the photoelectron cloud that can reproduce the non-sinusoidal waveform of potential difference between the probe and the spacecraft.

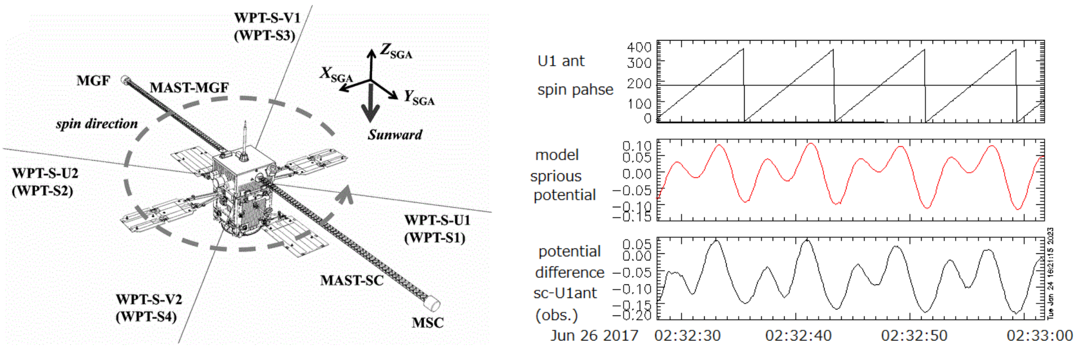

Figure 1. (left) Arase spacecraft [1]. (right) Spin phase of U1 antenna, model calculation of U1 potential, and observed potential difference between the spacecraft and the U1 probe.

References

[1] Kasahara et al., *Earth, Planets and Space* (2018) 70:86 https://doi.org/10.1186/s40623-018-0842-4.
[2] Kasaba et al., *Earth, Planets and Space* (2017) 69:174 https://doi.org/10.1186/s40623-017-0760-x.