

October 26, 2022

ISEE Award in 2022

Award Winner: Dr. Satoshi Kasahara (The University of Tokyo, Associate Professor)

Title: Outstanding contribution to space-earth environmental research by demonstrating the relationship between electron scattering and pulsating auroras in space

Citation:

Launched in December 2016, the geospace exploration satellite ERG (Arase) has conducted observations of geospace and radiation belts and has produced many scientific results. The Arase satellite has nine scientific instruments and functions. Dr. Kasahara designed and developed the Medium-Energy Particle Experiments – electron analyzer (MEP-e) and ion analyzer (MEP-i) to observe the plasma distribution function of tens of keV electrons and ions under severe radiation environment of the Van Allen belts.

Combining this MEP-e, and other instruments about the Plasma Waves (PWE) and Magnetic Field (MGF) onboard the Arase satellite, as well as ground-based auroral observation data, Dr. Kasahara and colleagues have identified for the first time that plasma waves cause the pitch angle scattering in collisionless space plasma and resultant precipitations into the loss cone are observed as the pulsating aurora in the ground. The pitch angle scattering by plasma waves has been theoretically predicted for more than 50 years. However, it has not been demonstrated by in-situ observations because the loss cone size is too small to observe by conventional particle instruments. The MEP-e developed by Dr. Kasahara has superior angular resolution compared to conventional particle detectors and has succeeded in observing directly electron scattering inside the loss cone for the first time, and he and his colleagues identified the origin of the pulsating aurora. This result has been reported in Nature and has an extremely large impact. In fact, the paper in Nature has already been cited more than 100 times and widely reported around the world. Furthermore, the paper has attracted significant attention, including being named the only Nature Editor's Choice in space science in 2018.

Dr. Kasahara has further exploited the capabilities of MEP-e to study the wave-particle interactions of chorus waves in the magnetosphere and found that the theoretical upper limit of electron scattering, i.e., the strong diffusion, by plasma waves into the loss cone, is reached

only near the magnetic equatorial plane from midnight to dawn sector.

The impact of the MEP-e and MEP-i observations developed by Dr. Kasahara has been extremely significant, leading to more than 45 scientific journal papers, including Nature, and other journals such as Nature Communications, Scientific Reports etc. The demonstration of electron acceleration processes due to nonlinear wave-particle interactions by chorus wave-particle interactions and the discovery of significant changes in the ion composition of the plasma sheet during magnetic storms and other new findings on geospace have been reported by his developed instruments.

Dr. Kasahara's works were carried out through the joint usage/research programs of the Institute for Space and Earth Environment (ISEE), Nagoya University. In the development of MEP-e and MEP-i, the calibration was performed using facilities operated at ISEE, which played a major role in improving its performance. Moreover, to achieve the result about the pulsating aurora, the correspondence between electrons measured by Dr. Kasahara's instrument, plasma waves, and ground-based auroral emission was identified by integrated data analysis using multiple instruments onboard the Arase satellite and ground-based optical observations. These data analyses were performed using the database and the integrated analysis software developed and maintained by the ERG Science Center, which is operated in cooperation with ISEE and the Institute of Space and Astronautical Science (ISAS) of JAXA. The ERG science center is currently being developed into the Center for Heliospheric Science.

Furthermore, Dr. Kasahara has organized various ISEE joint research meetings and workshops about the results of plasma/particle environment based on the Arase observations. Continuous discussions at these meetings and analysis workshops using the integrated data analysis software developed at the science center have led to the expansion of the results not only of this research about plasma/particle observations but also of the whole observations by Arase satellite and ground-based observations, making a significant contribution to the community development and the capacity buildings.

In summary, Dr. Kasahara has led the development of the MEP-e and MEP-i instruments onboard the Arase satellite and has produced excellent results by demonstrating the relationship between electron scattering processes by plasma waves in space and pulsating auroras at the ground. These are outstanding contributions to space and earth environment research, and therefore Dr. Kasahara is the most deserving recipient of the ISEE Award in 2022.

Related ISEE Joint Usage/Research Programs:

- 2022: International joint research
"Comet Interceptor mission equipment and ground system study"
- 2020-2021: General joint research
"Data Analysis of MEP-e and MEP-i on ERG Satellite"
- 2017-2019: General joint research
"Data Analysis of MEP-e and MEP-i on ERG Satellite"
- 2020: General joint research
"Development of calibration system for ion mass spectrometer on ultra-small satellite"
- 2017, 2019: General joint research
"Development of neutral particle mass spectrometer"
- 2016: General joint research
"Performance test of the MEPs flight model of the equipment on the geospace exploration satellite ERG"
- 2021: Joint Research Meeting
"Comet Atmosphere and Plasma Research Meeting"
- 2017-2019: Joint Research Meeting
"ERG Satellite Particle Observation Data Analysis Workshop"
- 2016: Joint Research Meeting
"Study Group on Radiation Belt Evolution Driven by Electromagnetic Ion Cyclotron Waves"

Related publications:

- Kasahara, S., S. Yokota, T. Mitani, K. Asamura, M. Hirahara, Y. Shibano, and T. Takashima, Medium-Energy Particle experiments - electron analyser (MEP-e) for the Exploration of energization and Radiation in Geospace (ERG) mission, Earth, Planets and Space, 10.1186/s40623-018-0847-z, 2018a.
- Kasahara, S., Y. Miyoshi, S. Yokota, T. Mitani, Y. Kasahara, S. Matsuda, A. Kumamoto, A. Matsuoka, Y. Kazama, H. U. Frey, V. Angelopoulos, S. Kurita, K. Keika, K. Seki, and I. Shinohara, Pulsating aurora from electron scattering by chorus waves, Nature, 10.1038/nature25505, 2018b.
- Kasahara, S., Y. Miyoshi, S. Kurita, S. Yokota, K. Keika, T. Hori, Y. Kasahara, S. Matsuda, A. Kumamoto, A. Matsuoka, K. Seki, and I. Shinohara, Strong diffusion of energetic electrons by equatorial chorus waves in the midnight-to-dawn sector, Geophys. Res. Lett., 46, 10.1029/2019GL085409, 2019.
- Kistler, L.M., C.G. Mouikis, K. Asamura, S. Yokota, S. Kasahara, Y. Miyoshi, K. Keika,

A.Matsuoka, I.Shinohara, T.Hori, NKitamura, S.M.Petrinec, I.J.Cohen, and D.C. Delcourt, Cusp and Nightside Auroral Sources of O⁺ in the Plasma Sheet, *J. Geophys. Res. Space Physics*, 10.1029/2018JA026413, 2019.

- Kurita, S., Y. Miyoshi, S. Kasahara, S. Yokota, Y. Kasahara, S. Matsuda, A. Kumamoto, A. Matsuoka, and I. Shinohara, Deformation of electron pitch angle distributions caused by upper-band chorus observed by the Arase satellite, *Geophys. Res. Lett.*, 10.1029/2018GL079104, 2018.
- Saito, S., S. Kurita, Y. Miyoshi, S. Kasahara, S. Yokota, K. Keika, T. Hori, Y. Kasahara, S.Matsuda, M. Shoji, S. Nakamura, A. Matsuoka, S. Imajo and I. Shinohara, Data-driven simulation of rapid flux enhancement of energetic electrons with an upper-band whistler burst, *J. Geophys. Res.*, 126, e2020JA028979, doi:10.1029/2020JA028979, 2021.
- Yokota, S., S. Kasahara, T. Mitani, K. Asamura, M. Hirahara, T. Takashima, K. Yamamoto, and Y. Shibano, Medium-energy particle experiments--ion mass analyzer (MEP-i) onboard ERG (Arase), *Earth, Planets and Space*, 10.1186/s40623-017-0754-8, 2017

Career summary of the award winner:

Satoshi Kasahara received a Ph.D. in science from the University of Tokyo in 2009. As a JAXA project researcher (2009-2011) and an assistant professor at the Institute of Space and Astronautical Science (2011-2016), he played a leading role in the development of medium-energy particle analyzers onboard the ERG (Arase) satellite. Since September 2016, he has been an associate professor at the University of Tokyo, working on analyzing data from Arase.

