# Investigation of the formation process of the source plasma driving SAPS fine structures found by Arase and SuperDARN

Takehiro Fukami[1], *Atsushi Kumamoto[1], Yuto Katoh[1], Nozomu Nishitani[2], Tomoaki Hori[2], Yasumasa Kasaba[1], Fuminori Tsuchiya[1], Mariko Teramoto[3], Tomoki Kimura[4], Yoshiya Kasahara[5], Masafumi Shoji[2], Satoko Nakamura[2], Masahiro Kitahara[2], Ayako Matsuoka[6], Shun Imajo[6], Satoshi Kasahara[7], Shoichiro Yokota[8], Kunihiro Keika[7], Yoichi Kazama[9], Shiang-Yu Wang[9], Chae-Woo Jun[2], Kazushi Asamura[10], Yoshizumi Miyoshi[2], Iku Shinohara[10], Simon G. Shepherd[11]

1. Graduate School of Science, Tohoku University, 2. Institute for Space-Earth Environmental Research, Nagoya University, 3. Kyushu Institute of Technology, 4. Tokyo University of Science , 5. Kanazawa University, 6. Kyoto University, 7. The University of Tokyo, 8. Osaka University, 9. Institute of Astronomy and Astrophysics, Academia Sinica, 10. JAXA ISAS, 11. Dartmouth College

Contribution of magnetospheric pressure inhomogeneities to subauroral polarization stream fine structures (SAPS-FS) is investigated on the basis of an event analysis of conjugated Arase satellite and SuperDARN observations.
SAPS is a strong westward flow in the subauroral region and an important magnetosphere-ionosphere coupling signature [Foster and Burke, 2002]. Previous studies reported various fine-scale and short-time variations within SAPS [e.g. Erickson et al., 2002; Mishin et al., 2003; Oksavik et al., 2006; Makarevich and Bristow, 2014]. There still have been many open questions for SAPS-FS, such as which spatial or temporal variations they are, and what kind of physical processes and source plasma in the magnetosphere generate SAPS-FS as observed in the ionosphere.
In order to address those questions, we analyzed SuperDARN-Arase conjugated observations on July 9th, 2017, which was carried out as a special campaign observation. SuperDARN Christmas Valley East radar observed the two-dimensional structures of SAPS-FS in the ionosphere. The fine structures moved equatorward and simultaneously extended westward. They merged and formed a latitudinally-broad SAPS 10-20 minutes after they started to be observed by SuperDARN. On the other hand, Arase traveled radially outward on the duskside in the inner magnetosphere and encountered four positive peaks of the outward electric field. Upon each passage of three of the four peaks of electric field, the satellite also detected eastward perturbation in the magnetic field. In addition, the three peaks were accompanied by enhancement of the hot ion pressure with a negative peak of the magnetic field intensity, which can be interpreted in terms of the diamagnetic effect. The first and second pressure peaks were formed by rapid enhancements of proton flux with small energy-time dispersion. It is suggested that the earthward and anti-earthward field aligned currents (FACs) were respectively generated at the earthside and anti-earthside edges of the ion pressure lumps. Since we could confirm that SAPS-FS in the event formed spatial structures on the basis of the continuous and two-dimensional SuperDARN observation, we can expect SAPS-FS sources also forms spatial structures in the inner magnetosphere. We examined the correspondence between SAPS-FS and the magnetospheric electric fields based on T04s magnetic field model [Tsyganenko and Sitnov, 2005]. While the one-to-one correspondence could not be identified, it was supported that the corresponding uniform structures were simultaneously formed in the ionosphere and magnetosphere in the event by coincidence of the estimations of the structure's size and speed in both regions. Our results support that the current generator theory can be applied not only to SAPS but also to SAPS-FS [e.g., Wang et al., 2019].
For this event, we performed a back-tracing of protons along their drift paths and also compared it with geosynchronous satellite data to discuss whether the particle injection into the inner magnetosphere could be the origin of SAPS-FS. The resultant drift calculation indicate that high-energy protons did not

 

come from the nightside plasma sheet to Arase under simple convection electric field as expressed in the Volland-Stern model [Volland 1973; Maynard and Chen 1975]. If an azimuthally-localized electric field, modeling those of substorm injection, added in the night side, the high-energy protons accelerated earthward and reach Arase. On the basis of the geosynchronous satellite observations, a signature of the single injection was found by GOES-13 prior to the SAPS-FS observation. The travel time between from GOES-13 to Arase is roughly consistent with the typical earthward speed of substorm injection reported by previous studies. These results suggest that the hot plasma was injected multiple times into the inner magnetosphere and formed fine-scale, enhanced pressure regions [e.g., Gkioulidou et al., 2014] during this SAPS-FS event.

Keywords: Subauroral polarization streams (SAPS), SAPS fine structures (SAPS-FS), Arase (ERG) spacecraft, SuperDARN, Particle injection

 