URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

The Ellipticity Polarization State of Transionospheric Radio Waves Using Swarm-E/e-POP RRI Satellite Observations and Modeling

Kuldeep Pandey[(1)], E. Ceren Kalafatoglu Eyiguler*[(1)], Donald W. Danskin[(1)], Robert G. Gillies[(2)], Andrew W. Yau[(2)] and Glenn C. Hussey[(1)]
(1) University of Saskatchewan, Institute of Space and Atmospheric Studies, Saskatoon, SK, Canada; kuldeep.pandey@mail.usask.ca
(2) University of Calgary, Department of Physics and Astronomy, Calgary, AB, Canada

The Swarm-E/e-POP satellite has an elliptical (325-1,500 km), polar (81° inclination) orbit and consists of eight scientific instruments dedicated to improving our knowledge of near-Earth space. The Radio Receiver Instrument (RRI) on e-POP can be configured as a perpendicular 6-m dipole pair [1] and provide observations on the polarization state of transionospheric HF waves. The received Faraday rotation of radio waves has been modeled [2] and extensively used to derive different ionospheric parameters. However, the investigations on radio wave ellipticity are limited [2, 3], and their observed variations need an explanation. In particular, the RRI observations have consistently shown circularly polarized radio waves to the north of ground transmitters (Saskatoon SuperDARN and HF transmitter at Ottawa, Canada) even when the wave propagation was transverse to the local geomagnetic field. Figure 1 shows a representative case of such observations.

This presentation addresses these unexpected observations of radio wave ellipticity using coordinated experiments between the RRI and the SuperDARN radar at Saskatoon, Canada (52.16°N, 106.53°W). In addition, a model [4] is used to calculate the expected relative strength of the individual wave modes (Ordinary-O and Extraordinary-X). Results show that the final wave becomes circularly polarized even when propagation is not transverse to the geomagnetic field provided one wave mode (O- or X-mode) dominates over the other by ~10-20 dB. These new findings improve our understanding of the polarization state of transionospheric radio waves by utilizing the ellipticity polarization state of radio waves, complementing the Faraday rotation observations from the orientation angle observations which have been extensively used.

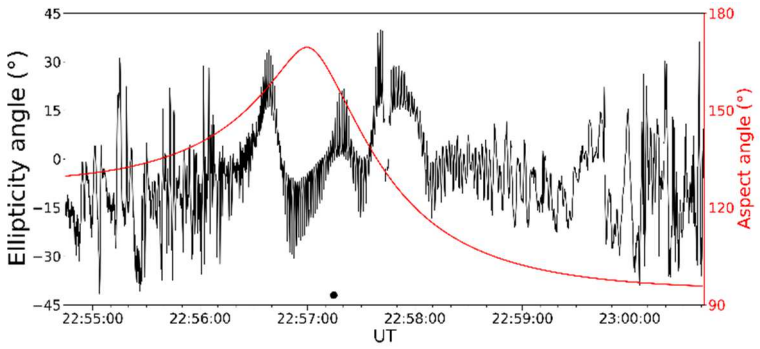

Figure 1. A representative case (19 April 2017) when circularly polarized waves were observed by the RRI even though the radio wave propagation was not transverse to the geomagnetic field. The black dot denotes the time when the e-POP satellite was closest to the ground transmitter.

References

[1] H. G. James, E. P. King, A. White, R. H. Hum, W. H. H. L. Lunscher, and C. L. Siefring, "The e-POP Radio Receiver Instrument on CASSIOPE." *Space Science Reviews*, **189**, 1, 2015, pp. 79–105, doi: 10.1007/s11214-014-0130-y.

[2] D. W. Danskin, G. C. Hussey, R. G. Gillies, H. G. James, D. T. Fairbairn, A. W. Yau, "Polarization characteristics inferred from the Radio Receiver Instrument on the enhanced Polar Outflow Probe", *Journal of Geophysical Research: Space Physics*, **123**, 2, 2018, pp.1648-1662, doi: 10.1002/2017JA024731.

[3] K. Pandey, E. C. K. Eyiguler, R. G. Gillies, G. C. Hussey, D. W. Danskin, A. W. Yau, "Polarization characteristics of a single mode radio wave traversing through the ionosphere: A unique observation from the RRI on ePOP/SWARM-E," *Journal of Geophysical Research: Space Physics*, 2022, doi:10.1029/2022JA030684.

[4] R. G. Gillies, G. C. Hussey, G. J. Sofko, and H. G. James, "Relative O- and X-mode transmitted power from SuperDARN as it relates to the RRI instrument on ePOP," *Annales Geophysicae*, **28**(3), 2010, pp. 861–871, doi:10.5194/angeo-28-861-2010.