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

Overview of the Plasma Wave Environment on the Endurance Sounding Rocket

Breneman, A.W.*(1), Collinson, G. (1), Pfaff, R. (1), Glocer, A. (1), Barjatya, A., Clemmons, J.
(1) NASA Goddard Space Flight Center, Greenbelt, MD, USA
(2) Embry Riddle Aeronautical University, Daytona Beach, FL, USA
(3) University of New Hampshire, Durham, New Hampshire, USA

The Endurance sounding rocket [1] was launched from Ny Alesund, Svalbard in May, 2022 into the sunlit polar cap to an altitude of 768 km with the goal of making the historic first measurements of the Earth's ambipolar electric field. This field is created by charge separation of fast electrons and slower, heavier ions and is responsible for enhancing ionospheric outflow including O+ over geologic timescales. It has previously been successfully measured at Venus and Mars [2], but due to its weak magnitude at Earth - predicted to be a fraction of a volt - the terrestrial value has yet to be measured. To make the necessary measurements, Endurance was equipped with a complement of instruments designed to measure cold plasma, energetic particles, and electric and magnetic fields, and plasma waves.

Though intentionally launched during quiet conditions required to observe the weak ambipolar field, the *Fields* package, which measured electric fields from two orthogonal 3.2-meter tip-tip double probes transverse to the magnetic field, and vector magnetic fields from a fluxgate magnetometer, observed interesting waves and structures from DC to very low frequency (kHz) to high frequency (MHz). These include density irregularities, 2-stream power in the lower E-region, VLF hiss, and, perhaps most interestingly, strong Bernstein waves with H+ cyclotron harmonic structuring at <500 km. The latter may be the first detailed observations of these waves in the sunlit polar cap. These waves exist at harmonics n>6 from 5 kHz up to the lower hybrid frequency, with lower harmonics likely damped by the predominant (~95%) O+ population. A synopsis of wave properties will be presented along with comparison of applicable theory of their origin and historical context.

References

[1] G. Collinson, "The Endurance Rocket Mission," *Space Science Reviews*, 218, 2022, 10.1007/s11214-022-00908-0.
[2] G. Collinson, "Ionosphere ambipolar electric fields of Mars and Venus: Comparisons between theoretical predictions and direct observations of the electric potential drop," Geophysical Research Letters, 46, 1168-1176, 2019, https://doi.org/10.1029/2018GL080597.