THE MAGNETOSPHERIC PLASMA TAIL

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The dynamic state of the Earth's plasma environment is most evident during the onset and early recovery phases of intense magnetic storms. By observing the time delays between storm-induced plasma changes it is possible to delineate structural relationships that always exist but are not readily apparent under moderate activity. For this reason, thermal proton density measurements by the rf ion mass spectrometer on the low-altitude polar-orbiting satellite OGO 4 were compared on five consecutive nightside passes during the early recovery stage of an intense storm occurring in September 1967. These observations revealed a new feature of the Earth's plasmasphere.

The storm considered is shown in Figure 1, which depicts the *Kp* variation for September. The *Kp* index reaches values higher than 7 just before our measurements. The five consecutive nightside passes studied immediately followed the peak of the storm.

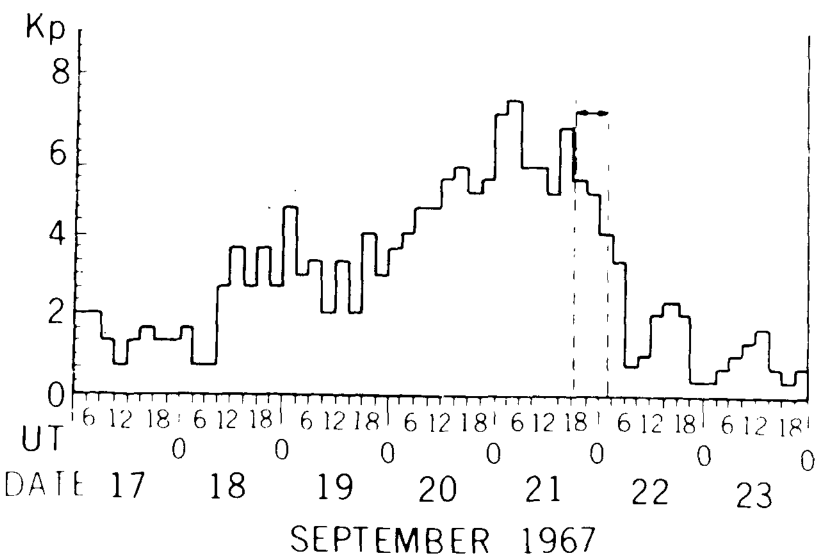

Figure 1–Magnetic storm depicted by the *Kp* variations. OGO 4 thermal proton observations were made during the period enclosed by the dashed lines.

Since the spectrometer was in a short sweep mode during this period, high spatial resolution of the H^+ density along the OGO 4 trajectory was obtainable. Figure 2 shows the proton density measured from north to south on each of the five consecutive nightside passes near midnight. The *L* coordinate denotes the equatorial geocentric distance of the magnetic field line passing through the satellite; increasing *L* values correspond to increasing magnetic latitudes.

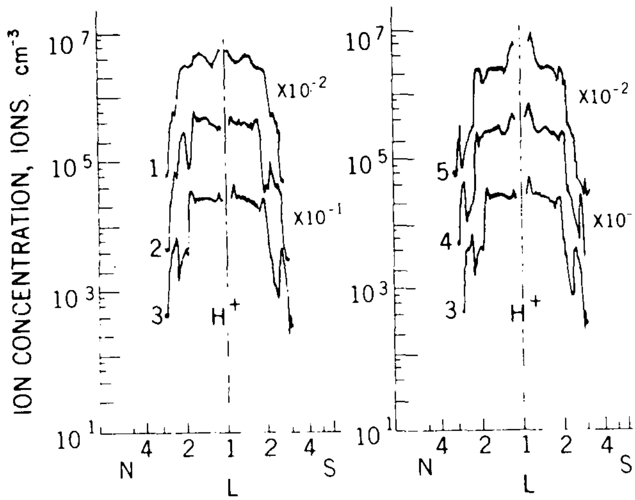

Figure 2–Proton density measured from north to south on each of five consecutive passes by OGO 4.

The first pass after the peak of the storm shows the characteristic termination of the dense plasmasphere. This boundary, known as the plasmapause, exists because plasma in the depleted region outside of the plasmasphere drifts onto magnetic field lines which connect to the interplanetary field, thus allowing a direct path by which the light ions can readily escape from the Earth's environment. The plasmapause is alined along magnetic field lines, as is readily apparent by the symmetry of its position about the equatorial plane.

On the second nightside pass, 1.5 hr later, a new feature appears – a secondary enhancement of the ion density poleward of the first abrupt plasmapause. On successive passes this enhancement region moves to higher *L* values, corresponding to higher latitudes. At the same time the thickness of this region of enhancement tends to decrease; after the fifth midnight pass, we could no longer detect the enhancement.

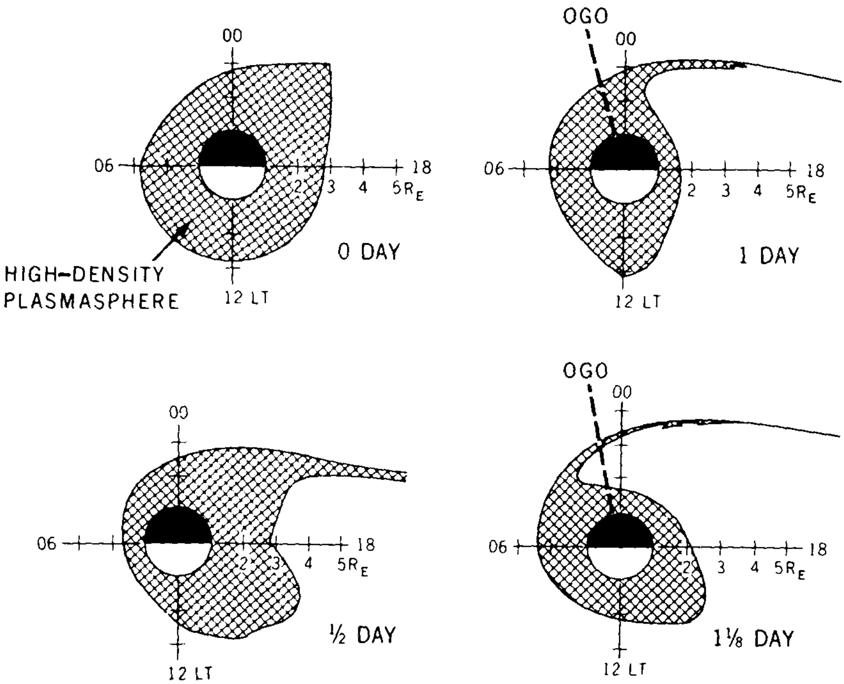

Figure 3–Model calculation of the high-density plasmasphere.

To give better perspective to the observations, a simple calculation is shown in Figure 3.

One day before the measurements the plasmapause variation with local time was taken as that typical of the average steady-state configuration with a bulge occurring in the dusk-midnight sector. Since the drift motion of magnetosphere plasma is a superposition of corotation with the Earth and a solar-wind-induced flow from the magnetosphere tail, the evolution of the plasmapause was computed by varying the magnitude of the tailwind in step with the *Kp* index as depicted in Figure 1. As shown, the September storm variation produced an elongated plasma tail attachment to the plasmasphere. The cusp of the streamer tends to rotate during the recovery phase of the storm through the satellite trajectory near midnight.

Along the orbit of OGO 4 this characteristic tail would produce an enhanced region of ion density poleward of the bulk of the plasmasphere. This secondary peak of ion density would move to higher latitudes as the tail sweeps by the trajectory of the satellite and at the same time the thickness of the enhancement region would decrease, as was observed by the satellite.

Hence the OGO measurements can be accounted for by the existence of an elongated plasma tail during the recovery phase of this storm.

Although considered here after an intense storm when tail development is pronounced, such a structure or even multiple tails of this type should also exist during relatively quiet magnetic conditions. Such extremely thin plasmasphere extensions would account for the irregularities often observed near or outside the body of the plasmasphere and could explain the origin of discrete elf emissions often observed in the depleted region known as the trough.

CHAIRMAN:

Any questions?

MEMBER OF THE AUDIENCE:

Was the OGO 5 operating at the same time as these measurements?

DR. GREBOWSKY:

No, it was not.