Variable Subcorotation of the Earth Plasmasphere: Ongoing Studies with IMAGE/EUV

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EUV He^{+} 304 A images of the Earth plasmasphere show notches (byte outs) along the plasmapause lasting 10s of hours. Tracking these isolated features Sandel *et al.* (2003) have found that the subcorotation of the plasmasphere of ~12% average (7–23%, 13 cases, $L = 2$–4) Case 1 of Sandel et al. shows fairly steady subcorotation. Using DMSP $z \sim 800$ km data showing corresponding westward ionospheric plasma drifts, Burch *et al.* (2004) inferred that the subcorotation is due to ionospheric disturbance dynamo. This would be induced by auroral energy deposition and Joule heating driving equatorward neutral winds that bend westward by Coriolis forcing, operating at $z \sim 120$ km and at all local times during active auroral periods (Blanc and Richmond 1980).

On the other hand, Case 2 of Sandel *et al.* shows time variation possibly dependent on m.l.t. For example, the magnetospheric convection E field could be penetrating to lower L-shells than expected. We are searching the EUV database for cases with notches, radial plasma fingers, and plasmapause protrusions lasting 10s of hours. Here we will present the subcorotation observed in 5 cases, the 2 from Sandel *et al.* and 3 others, as a function of: m.l.t., L-shell, solar wind IMF, global geomagnetic activity Kp index, ring current disturbance storm Dst index, and auroral activity for which we were using the AE index but will now use instead the auroral hemispheric power output derived from daily or nearly simultaneous auroral images taken with the IMAGE FUV instrument. (The IMAGE EUV analysis is made using the euv_imtool software developed here at LPL, where each image pixel corresponds to the minimum L-shell from where 50% of the He^{+} emission originates.)

We will depart from Case 1 that agrees with an auroral ionospheric disturbance dynamo explanation, and then show other behaviors that agree or disagree with this subcorotation source process. Much temporal variation is observed. Case 1 showed sustained subcorotation of the plasmasphere that lasted 60 hours, while the auroral activity was high, and thus, when the subcorotation could have been driven by the proposed auroral ionospheric dynamo. Cases 2 and 3 show variable subcorotation for about 45 hours, showing subcorotation after dusk but not after dawn, and this is what would be expected if driven by the magnetospheric convection electric field. With respect to auroral activity, the subcorotation changes in Case 2 were synchronized with similar magnetospheric and auroral activity changes but this was not the situation in Case 3. Still, in these Cases 2 and 3, the 12 hour temporal changes observed would have been too fast for a pure auroral control, since the auroral ionospheric dynamo should have longer decay time scales as theoretically considered. We may have found one example, Case 4, which may show such a longer decay time scale.

Case 4 consisted of 5 days when there was first a strong erosion of the plasmasphere accompanied a strong aurora (due to strong substorm activity induced by southward solar wind magnetic field IMF). Then the solar wind IMF, in particular Bz, became essentially zero for 10s of hours. The main plasma pattern froze up and started refilling hours later. After Bz turned zero, the plasmasphere continued subcorotating for 19 hours, which is close to ~24 hours decay time scale of auroral Joule heating or ionospheric inertia proposed by Blanc and Richmond (1980). Afterwards full corotation was observed for 40 hours while the IMF remained ~ zero. Subcorotation resumed 15 hours after a very weak Bsouth resumed and Kp remained minimal (<2) until last 2 hours of observation. But meanwhile, the AE and the ionospheric winds were minimal (as per DMSP maps). So we do not known what prompted subcorotation to resume! Was it a magnetospheric electric field? Or was it a high latitude aurora? The IMAGE/FUV data will be crucial to clarify what was happening with the aurora in this period.

Finally, Case 5 shows a radial plasma finger of enhanced plasma density in which we have measured 24% subcorotation at $L = 1.15$, progressively decreasing to 5% subcorotation at $L = 3$. This is measured from pre-dawn to pre-dusk. This result agrees with the above cases 1-3, for example, since at $L = 3$ we see little subcorotation. Thus, low-latitudes can show stronger sub-corotation. Kp went from low (~ 2) to high and all L shells increased subcorotation in the last 6 hours, when all activity indicies were higher. In the ionosphere, low latitude subcorotation has been observed at active times but also at quiet times of Kp < 3 and is believed to be due to low latitude l.t. dependent neutral wind dynamos (Richmond 1980; Kelly 1989, Chapter 5).

Although the work is still in progress, the results so far show that much temporal variation is present in the degree of subcorotation of the Earth's plasmasphere that should serve as diagnostics of the processes at play.