Properties of Slow-mode Shocks in the Distant (>200 R_e) Geomagnetic Tail

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The two distant ISEE-3 geomagnetic tail passes have been examined to identify all slow-mode shocks present in the data. We find a total of 86 events from 439 plasmasheet/lobe crossings, using five criteria based on relations between the upstream lobe and the downstream plasmasheet magnetic field and plasma measurements. The statistical results of slow-mode shock parameters such as the angle between magnetic field and shock normal, θ_{Bn}, Alfven Mach number along the normal direction, M_{An}, and electron beta, β_e are calculated and reported. On average, the magnetic field decreases by a factor ~2.7, the electron density increases by ~1.7, temperature increases by ~1.8, and the plasma flow velocity increases by ~3.8 across the shocks. The average upstream θ_{Bn} is ~76° while the downstream angle is ~ 50°. The shocks have an average M_{An} ~6.87 along the normal direction, and an upstream β_e ~0.04. In the downstream plasmasheet region, the dominant plasma flow associated with the shocks is in the tailward direction with an average speed ~585 km/s. Only a few cases of earthward downstream plasma flow have been detected. The slow shocks have thicknesses, on average, of ~5380 km (about 7 ion inertial lengths) and an average tilt angle of ~22.4° between the shock normal and z axis. Using the Petschek slow shock model, the average location of the neutral lines is located in a range of ±40 R_e from observation sites. About half the slow mode shock events are detected during southward IMF intervals and half during northward intervals. There is a weak substorm dependence of slow mode shocks and plasmoids, a dependence which is most obvious when B_z > +2 nT and B_z < -2 nT intervals are intercompared. We see a substorm dependence for plasmasheet/lobe crossings which suggests that the deep tail become more dynamic during substorm intervals. We have also sought the existence of large wavetrains downstream of slow shocks that have been theoretically predicted by Coroniti (1971) and simulation studies. No such wavetrains were observed throughout the two ISEE-3 passes of the distant tail. However, we do detect some medium amplitude transverse waves in the shock ramp regions. The waves have frequencies and polarizations similar to the plasmasheet boundary layer waves reported by Tsurutani et al. (1985). The waves present in the shock ramp are also right-hand ion cyclotron waves in the plasma frame. We believe that these waves are generated by the ion beams flowing away from the magnetic merging regions.

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