

npg-2009-22, Pickett et al.

Response to Referee No. 2:

We thank the referee for his/her insightful comments. We have addressed each of his/her concerns as follows:

1. Cluster electric field measurements cannot determine if the bipolar ES structures are parallel to the background magnetic field or not. In the experiment, presumably they are parallel.

Answer: Cluster cannot determine if the ES structures are parallel to the magnetic field or not, but it can determine the angle between the measuring antenna and the magnetic field ($\theta_{\text{Ant-B}}$). If the ES structures are propagating parallel or anti-parallel to the magnetic field, a necessary condition for this to be the case is that $\theta_{\text{Ant-B}}$ must preferably be near 0 or 180 degrees, or at least not close to 90 degrees. This is indeed the case for all of the ESWs observed during and following the super-substorm onset. For the LAPD experiments, yes, they are parallel. We have clarified these two points in the paper at the end of Section 2.1 and in Section 3.

2. The bipolar ES structures observed in both are presumably stationary spatial structures moving by the probe, yet the analysis describes them as "similar" because both are on the time scale of the inverse electron plasma frequency. This frequency is irrelevant unless the structures measured by Cluster and the structures measured in the laboratory are both moving at their respective electron thermal speeds. However, the speed of the structures in space is unknown, so no conclusion can or should be drawn regarding any similarity. In the same vein, the frequency analysis of the ES structures observed on Cluster would seem to be misguided.

Answer: We have dropped the word 'similar', and simply state the measurement facts. In Polar observations of ESWs at the plasma sheet boundary layer (which is the relevant region to this study), the ESWs propagate typically at around the electron thermal speed or higher [Franz et al., JGR, 2005]. Even though Cluster WBD cannot measure speeds of ESWs, the fact that ESWs have time durations comparable to the electron plasma period suggests that they might propagate at the electron thermal speed. We have indicated this in the paper near the end of Section 2.1.

3. It is stated in the description of the Cluster results that the comparable abundances of H+ and O+ is significant during the appearance of ES structures. Are there comparable ion species in the LAPD experiment also?

Answer: There is only one single ion species in the LAPD experiments. The multiple ion species are likely not relevant at all as far as the ESW generation mechanism is concerned, because the ESWs are most likely due to electron dynamics, and from the electrons' point of view, the velocity and inertia differences between the two ion species are unlikely to matter. This is noted at the end of the Conclusions.

Speculations concerning the origin of the ES structures need to be qualified.

1. The structures can only correspond to ion - acoustic solitons if the electrons are much hotter than the ions and there are NOT two counterstreaming electron beams.

Answer: For the LAPD experiments, the ion-acoustic solitons can certainly be ruled out since the ESWs propagate at a few hundred km/s, while the ion-acoustic speed is a few km/s. In addition, it would be hard to come up with a scenario to generate ion acoustic solitons with the observed structure time scales for either the space or laboratory based experiments. We are not aware of any such scenarios. Some clarification on this issue has been added to the paper in Sections 3 and 4 .

2. Also, even though the electrons are measured over many waveform times, their distribution can still be relevant to the waveform when there are many waveforms appearing during an electron measurement time. It is not likely that an unstable two stream electron distribution would be found, but rather a (saturated) broad - top distribution in which the velocities between the two original beams have been populated. For such a case the relevant electron temperature is actually the energy associated with the difference velocity between the two beams. The expected ES structure speed under these condition would be 0.5 times this thermal velocity.

Answer: We agree. The velocity consideration is why we rule out the two-stream instability for LAPD ESW generation as now noted in Section 3, but cannot do the same for space ESWs.