npg-2009-22, Pickett et al.

Response to Referee No. 1:

We thank the referee for a thoughtful and constructive review of our paper. We have addressed all of his/her concerns as follows:

1) In the introduction (page 2) the content of the second paragraph from: "Although super-substorms" to "passages of the disturbances" must be suppressed. It is far too much concentrated on the description of the characteristics of the present substorm.

Answer: We respect the reviewer's opinion and have thus removed the description of the characteristics of the super-substorm, as requested.

2) It would be worth to mention in the introduction that several works have been previously performed to show that some broadband electrostatic emissions are associated with reconnection and have some nonlinear coherent structures:

· Pottelette and Treumann "Impulsive Broadband Electrostatic Noise in the Cleft:a Signature of Dayside Reconnection", J. Geophys. Res., Vol 103, N°A5, p 9299-9307, 1998;
· Matsumoto et al., "Observation of Electrostatic Solitary Waves associated with reconnection on the dayside magnetopause boundary, Geophysical Res Lett, 30, 1326, doi:10.1029/2002GL016319, 2003.

Answer: The two references have been added and cited in the Introduction and Discussion sections with appropriate reference to reconnection.

3) A key reference paper is also forgotten in the list dealing with the generation of electron acoustic instability; the one by: Berthomier, M., R. Pottelette, M. Malingre and Y. Khotyaintsev, " Electron acoustic solitons in an electron-beam plasma system", Phys. Plasmas, Vol 7, N°7, 2000.

Answer: We agree that this is a key reference and thank the reviewer for pointing out our omission. It has been added to the references and cited in the appropriate places in the Introduction and Discussion sections.

4) Note that a kinetic Buneman instability has also been mentioned for phase space holes generation (Goldman, M. V., Newman, D. L., and Ergun, R. E.: Phase space holes due to electron and ion beams accelerated by a current driven potential ramp, Nonlin. rocesses Geophys., 10, 37–44,2003).

Answer: We agree that it is important to specifically note this type of instability. It has been cited in the Introduction and Discussion sections with a reference to the kinetic Buneman instability, mentioned as a possibility in the Abstract and Conclusions, and the noted reference has been added to the References.

5) Again the paragraph (page 4) starting by "Preliminary analysis…." Up to " in November 2006" must be suppressed.

Answer: We have suppressed most of this paragraph as requested, but felt it was necessary to provide a link to information about the substorm for those whose primary interest is substorms and wishing to make a link between ESWs and this particular substorm. Thus we have kept the last sentence of this paragraph which begins "For more information…" and moved it to the end of the first paragraph in Section 2.

6) Regarding the description of Figure 2, it would be interesting for the reader to know that the spacecraft are moving northward from the internal plasma sheet into the lobes with increasing time.

Answer: We have added the requested spacecraft location information to the Fig. 2 caption and to the text in the Abstract, Section 2.1 and Conclusions.

7) With regards to Fig 1, would it be possible to reduce the plotted time period from 9H30 up to 10H45. With this reduced time period, it should be possible to see more clearly the time delays of the disturbances recorded on each of the three spacecraft.

Answer: Because the Cluster WBD data are extremely high time resolution, reducing the plot interval to 0930-1045 UT as requested does not show the time delays as expected because many spectral slices are still being averaged across the entire plot. We have thus left Fig. 1 as originally submitted covering 0900-1100 UT. We also feel that adding two more figures to illustrate these time delays where averaging of spectral slices has not occurred (which would need to be plots of 30 seconds or less) will make the paper figure-heavy with little gain. We have decided, therefore, to make no change to the figures or text. We mention the order of the delays and the simple conclusion of the direction of the disturbance based on the order.

8) The sentence "They were first observed in space on the S3-3 spacecraft" might be confusing. As far as the present referee knows, the coherent isolated pulses measured by S3-3 were related to ion holes and not to electron holes.

Answer: The S3-3 paper discusses more the double layers than the solitary waves. In fact the paper does not mention that the solitary waves are electron or ion holes. The term "Electrostatic Solitary Waves" in and of itself does not imply electron holes as opposed to ion holes. In fact only through interpretation of various aspects of the data can we conclude that they are even phase space holes. Thus, we believe that our statement is not misleading. However, in order to avoid any confusion, in the third to last paragraph of Section 2.1 we have changed "They were first observed in space on the S3-3 spacecraft (Temerin et al., 1982)" to "Small amplitude solitary waves containing magnetic-field aligned electric field components were first observed in space on the S3-3 spacecraft (Temerin et al., 1982) in the auroral region, but these solitary waves were not identified as to the type of structure they represented (i.e., phase space holes or density enhancements or depletions)".

9) It is mentioned (end of page 5) that the observed ESWs in the auroral bulge phase have time duration substantially shorter than those observed both before and after. Does that mean that the plasma density is substantially increased during this time period?

Answer: The shorter ESW time durations observed in the bulge phase are due to enhanced field-aligned (in both parallel and anti-parallel directions, consistent with the mixed electric-field polarity of the ESWs) electron fluxes as shown in the first and third panels of Fig. 7. The plasma density in the bulge phase is lower than that before the bulge and higher than that after the bulge (the bulge phase is a transition stage), according to the density measurements from CIS (see Panels 1 and 2 of Fig. 6), EFW, deduced from the spacecraft potential measurements, and Whisper sounder measurements, the latter two not shown in the paper but referenced through private communication (P. Décréau). We have added a couple of sentences of explanation about this in the second to last paragraph of Section 2.1

10) Is the program which automatically detects the characteristics of ESWs able to detect also the different polarities of these nonlinear structures? If yes, these informations would be very interesting to provide! Are all the detected ESWs of the same polarity?

Answer: The automatic detection program can detect the electric-field polarity of the pulses, but not the polarity of solitary potentials since WBD simply measures the potential difference between two electric field spheres. We have added a note of explanation about this at the end of Section 2.1

With regard to whether all detected ESWs are of the same electric-field polarity, they are not. In fact in intervals as small as a few ms we can see ESWs with opposite electric-field polarities (referred to the first excursion of the bipolar pulses) which cannot be attributed to the spinning antenna's orientation with respect to the ESWs' propagation. However, we do not know whether these are ESWs of the same potential polarity traveling in opposite directions, or whether they are opposite potential polarities traveling in the same direction. If the ESWs are of similar time duration as is usually the case, we would tend to favor the former explanation, and this is consistent with the enhanced directional fluxes of electrons both parallel and anti-parallel to the magnetic field (see Fig. 7). However, we stress that there is no way to prove this with the WBD data alone. . We are considering some methods that rely on other Cluster data to try and eventually be able to sort our ESW polarities in some events. We have discussed this polarity issue at the end of Section 2.1.

11) What is the magnitude of the Debye length in the LAPD and why the plasma can be considered as collisionless?

Answer: The Debye length for the particular run reported is about 56 μm. The electron-electron collisional mean free path is about 17 cm, while the measurement was taken at approximately 6 cm from the beam source. The electron-electron collisional frequency is 1.1 MHz, while the electron plasma frequency is 528 MHz. Based on the above numbers and that the reported solitary wave has a time scale comparable to the inverse plasma period, the plasma is considered as collisionless. We have added some explanation in this regard to the paper in Section 3.

12) What kind of instability is inferred at the place where the ESW is detected in the LAPD.

Because the LAPD solitary structures were all observed to propagate at about the background electron thermal speed, which is only a few percent of the beam speed, we have ruled out the two-stream instability as the generation mechanism for the LAPD ESWs (Section 3 now states this and we have also included it in Section 4.). However, the responsible instability is yet to be identified.

13) Page 10. Again, it would be fair to mention also the Buneman instability for the generation of ESWs. This latter instability is driven by the relative ion/electron motion and is thus directly connected to the current! Note that the two-stream instability is the simplest instability (cold electron fluid) which in practice rarely occurs, because other instabilities set in before it can develop.

Indeed we cannot rule out the Buneman instability for the space observations of ESWs with longer time durations. However, the very short time duration ESWs observed in the auroral bulge phase with time scales only slighter larger than the electron plasma period are expected to be produced through electron dynamics, thus ruling out the Buneman instability for these short time duration ESWs. This is now discussed in Section 4. For the LAPD experiments though, the condition is not the classical Buneman condition. This is because at least 90% of the electrons are at rest with respect to the ions (the beam density is less than 10% of the background density). The Buneman instability scenario discussed in Goldman et al. [NPG, 2003] is not relevant to the LAPD solitary waves because the predicted velocities of the phase-space holes (moving at the ion speed) would be too slow to account for the LAPD ESWs. A statement regarding this has been added to the end of Section 4.