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Nonlinear Processes in Geophysics
Discussions
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# *Interactive comment on* "The double layers in the plasma sheet boundary layer during magnetic reconnection" *by* J. Guo and B. Yu

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Response to the Referee Many thanks for your very constructive report. The manuscript has been revised following your comments and suggestions. Please note that in the revised manuscript, all of the paragraph except for 'Simulation Model' are rewritten, then we just list the paragraph rather than to say the lines in the reply. In what follows, your comments are listed in their original order, followed by our response and the corresponding revisions. Please note that the page numbers referred to in this letter are for the revised manuscript. In addition, all new references introduced during this revision have been properly included in the reference list.

This paper reports numerical results from 2D PIC simulations of magnetic reconnection, showing formation of double layers in regions well removed from the electron



diffusion region. I find that the numerical results have been reported without giving any discussion on the physics of the formation of double layers and their subsequent evolution to triple layers. Therefore, for a reader like me the paper raises many more questions than it answers. I have some questions here for the authors to address before the paper is accepted for publication in NPG.

1. Figure 2 is an important figure in the paper, but it is made so miniscule that almost nothing can be deduced as to the structure of the unipolar electric fields and the associated charge separation that supports it. The unipolar field of a double layer necessarily implies that it is supported by two separate layers of charges, a positive and a negative charge layer. Likewise a triple layer should have its charge separation supporting the electric field. However, the density plots in Figure 2 are not very helpful. Only thing I can see from the density plots is the alternating layers of positive and negative charges separated by distances much larger than the size of the unipolar fields. So my suggestion is that the author identify one unipolar layer, and use both horizontal and vertical scales so that charges supporting the fields and the associated phase-space structures of particles can be clearly identified.

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Thanks for pointing this out. We have revised the figure and please take a look at the parts that are added on page 5 and figure 2.

2. How does the unipolar double layer originate? Is it driven by some plasma instabilities? Are Buneman or ion-acoustic modes involved in the origination process? Or do the fields emerge from the charging of density cavities by the currents along x? In presence of currents, double layers emerge when preexisting cavities charge to set up fields to accelerate electrons locally to maintain the current continuity. This was studied in a series of Vlasov simulations of double layers by Singh published in GRL and JGR in 200-2003 time frame.

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Thanks for pointing this out. We have rewritten the paper and carefully studied the excitation of the DL. Please take a look at the parts that are added on page 3,5-6. The wave spectrum of parallel electric field is also added, please look at the paragraph 3 on page 5.

3. I find that the authors are not aware of literature on double layers (DLs), the earliest simulation work on current-driven double layers was published in GRL 1982. The triple layers formation with a potential dip on one end of the DL and a hump on the other end was found in simulations by Singh and Schunk published in Plasma Physics and Controlled Fusion (PPCF) in 1984. Sometimes instabilities create density cavities that charge yielding double layers. This PPCF paper describes how a triple layer emerges as a result of the DL's attempt to maintain over all charge and current balance. More recently Pottelette (Ann. Geophys., 32, 677–687, 2014, and references therein)) has discussed triple layers in the auroral plasma. I suggest that the authors to consult these papers (or otherwise) to explain as to why the electric field structures with single and triple layers form in their simulations.

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Thanks for pointing this out. We have rewritten the paper and mainly focused on the double layer. Please take a look at the parts that are added on page 3.

In summary I suggest that the before the authors should publish their simulation results, they provide physical explanations for what they see from the simulations. The double and triple layers should be clearly identified in terms of space charges supporting the structures. The current-driven double layers were not discovered in 2001 as implied by the references; they were found in simulations and also in lab experiments at much earlier times. The authors should cite the appropriate/relevant literature.

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Thanks for pointing this out. The physical explanations about double layer have been



provided in our work. Please take a look at the parts that are added on page 5-6. And also, the references are rewritten. Please take a look at the parts on page 9.

Please also note the supplement to this comment:
http://www.nonlin-processes-geophys-discuss.net/1/C902/2015/npgd-1-C902-2015-supplement.zip

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