

Ann. Geophys. Discuss., referee comment RC2
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Comment on angeo-2021-32

Anonymous Referee #2

Referee comment on "Dynamics of variable dusk–dawn flow associated with magnetotail current sheet flapping" by James H. Lane et al., Ann. Geophys. Discuss.,
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General comments:

In this paper, observations by Cluster satellites are presented from a time interval during which earthward convective magnetotail plasma flows exhibit dusk-dawn sense that disagrees with the previously invoked tail field line untwisting hypothesis (under the influence of nonzero IMF B_y), while in contrast, the prevailing IMF B_y conditions and the ionospheric convection data measured by SuperDARN radars indicate a large-scale magnetospheric morphology consistent with positive IMF B_y influence. For the first time, $\mathbf{J} \times \mathbf{B}$ force acting on flowing plasma is estimated in nonzero IMF B_y conditions, and it is suggested that in this case, the $\mathbf{J} \times \mathbf{B}$ force associated with a flapping of the magnetotail current sheet is locally overriding the expected IMF B_y control of the flows.

The paper presents an interesting event study of dynamic tail behaviour during nonzero IMF B_y conditions while IMF B_y looks like not to affect the flows in this case. The manuscript might be worth publishing after the authors have addressed a few concerns/comments, which are presented below.

Specific comments:

Main comments:

Lines 585–645: My main concern is how well the curlometer current \mathbf{J} and the $\mathbf{J} \times \mathbf{B}$ force

can be used to describe this dynamical situation. Because of the large inter-spacecraft separation of the spacecraft, the estimates of these quantities are averages over a large volume. The flapping of the current sheet is observed only in one part of this volume. Should one compute these quantities specifically for C1 if that would be possible? If one assumes that the computed current J is stable and represents the current over the region covered by the Cluster tetrahedron, would it be reasonable to compute the $J \times B$ force using that J and then the B field measured only by C1? That would be a more local estimate for the $J \times B$ force at the C1 position. The authors could compute that and compare to the present estimate.

Lines 525-532, Summary and Abstract, lines 106-107: Second, the typical extents of the IMF B_y penetration that is overriding the tail field line flaring (and causing tail magnetic field line twisting) in the case of clearly nonzero IMF B_y (IMF $|B_y| > 3$ nT) can be seen in Figure 2 of Pitkänen et al. (2019, GRL). Their Figure 2a and 2b show that under clearly positive IMF B_y conditions, the (slow) earthward convection is expected to be on average duskward both above and below the neutral sheet at the position of the Cluster spacecraft of the present manuscript. The tail magnetic field in this position is expected to be governed by the flaring. In the case of the present manuscript, the magnitude of positive IMF B_y was mostly less than +3 nT. Therefore, the global flow pattern in the magnetotail could be assumed to be even less asymmetric and the tail field line twisting occur at smaller extents than in Figure 2 of Pitkänen et al. (2019). The Cluster magnetic field data (C2-C4 data) clearly demonstrate the appearance of the field line flaring in the case of the present manuscript and not the twisting of the field lines due to IMF B_y influence. Furthermore, I think that while model results, Figure 5b in the present manuscript nicely demonstrates the spatial limits of the IMF B_y penetration to twist the tail magnetic field lines.

The authors could modify the Summary section and add there that in this event, the IMF B_y influence in the position of Cluster was not strong enough to twist the magnetic field lines and the measured flows were associated with the localized magnetic field perturbation. So, the current sheet flapping was not overriding the IMF B_y control, because the control did not exist at the location of Cluster. Also then the end of the abstract (and the text elsewhere where IMF B_y overriding is discussed) would need to be modified.

Other comments:

Line 401: Maybe write here "the Harang reversal" instead of "the Harang discontinuity", because the authors are investigating flows.

Line 701: Which plasma sheet magnetic field observations the authors do mean here? The TA15 model results?