

## Response to Referee Comment 2

Yann Pfau-Kempf on behalf of all co-authors

March 28, 2025

Thank you very much for the kind words and constructive review, which will help improving this paper. We reply point-by-point below (*in italics*).

Line 1: The term “rolled-up” is used to describe magnetic flux ropes. While not incorrect, “helical magnetic field” is more commonly used and precise. Also, the term “longitudinal axis” is not clear and should be clarified as it can vary in different space plasma contexts.  
*We will rephrase this sentence.*

Line 16: The word “twisting” is used to describe the magnetic field geometry of flux ropes. Again, “helical” is a more accurate and commonly used term.  
*We will also rephrase this sentence.*

Lines 18-21: The description of flux rope formation suggests they originate inside the Sun and pass through the solar surface. I do not think this is the case. References are needed if this is the case. On the other hand, this should include the possibility of formation by magnetic reconnection in the solar wind, as noted by Cartwright and Moldwin (2008) and Feng (2010).  
*The emergence of flux ropes is the topic of both references that were given.*  
*We will add the possible formation mechanism through reconnection in the IMF and the references, thank you for this suggestion.*

Line 25: The phrase “When the magnetotail current sheet disrupts and reconnects, flux ropes form” should be revised to “When the magnetic field reconnects in the magnetotail current sheet, flux ropes can form.”  
*It will be revised.*

Lines 52-53: May mention the automated method developed by Li et al. (2023) for detecting FTEs in Mercury’s magnetosphere.  
*Thanks for pointing out this method too! It will be included.*

Figure 1: Consider including a panel showing the curvature radius along with the magnetic field line for better illustration.  
*We will include this information in the figure.*

Section 2.2. The simulation in this study was under a pure southward IMF. Therefore, the flux ropes resulted from this simulation likely do not have strong core

field. How does the core field influence the criteria set up here?

*The effect of a stronger core field is discussed in Section 5.3. We will rephrase the section slightly to distinguish reconnection guide field from the flux rope core field, which were both called guide field so far.*

On the other hand, is it possible to investigate the curvature radius in a flux rope event with a strong core field or a flux rope without core field in the simulation? As shown in Sun et al. (2019, 2019GL083301) and Smith et al. (2024), flux rope with strong core field corresponded to a maximum in curvature radius, while without strong core field a minimum in curvature radius.

*The method certainly remains applicable in higher core field configurations. Although it will possibly not detect points near the core of the flux rope, it will still detect surrounding regions and thus allow identification of the flux rope. This is also discussed in Section 5.3.*

Lastly, flux transfer events often correspond to coalescence, i.e., merging of neighboring flux transfer events, as shown in Sun et al. (2022, *angeo-40-217-2022* and many other simulation and observation works). Is it possible for this technique to identify those events?

*Future work based on the detected flux rope regions will certainly allow identifying individual flux ropes, tracking them and why not seeing if they coalesce with each other.*

Line 162: Clarify the term “Neumann (copy).”

*We will rephrase to explain the Neumann condition, which is the same as copy condition.*

Line 168: Revise “for on” to “on.”

*We will rephrase this.*

Line 205: I think that I can identify the “long flux rope” and the “curved flux rope”.

However, it would be better to identify them in the Figure.

*We will highlight in Fig. 2 and 3 the flux ropes in question as well as the flux ropes that are shown in Fig. 5 and 6 to make it easier to follow.*

Line 226: Add citations for MGA and MDD.

*We will add the reference to the review by Shi et al. (2019)  
<https://doi.org/10.1007/s11214-019-0601-2>.*

Figure Captions (Figures 5 and 6): Clarify the abbreviation “resp.”

*Will be clarified.*

Figures 5c to 5f, may include horizontal lines at  $y = 0$ .

*This will be included.*

Figure 6 pretty nicely shows the flux ropes!

*Thank you!*

Lines 280 to 281: Is it possible that the counter-rotating vortices of magnetic field lines are coalescing flux ropes as I mentioned earlier?

*As they are counter-rotating the field is parallel and not antiparallel in between, as shown by the in-plane magnetic field lines in Figure 5(a). So there cannot be any coalescing through magnetic reconnection here. Taking the red-to-blue transition as being close to the flux rope core, Figure 5(a) and (b) show that the flux rope is bent in a crescent shape.*

Line 290: “more inclined along the main diagonal of the (x,y)-plane” Is this place trying to say that the axis of the flux rope is mainly in the x-z plane?

*Yes indeed. The paragraph was rephrased and expanded to better convey the shape of the flux rope.*

In Figure 7, the contour for the x within 4 to 12 RE is larger than the contour for the x within 0 to 4 RE. I could not understand why. Could the authors explain more about this?

*The larger, yellow contour from 4 to 12  $R_E$  comprises essentially all of the subsolar dayside magnetopause including the region where the FTEs reconnect with the cusp/lobe magnetic field. The next, orange contour at 0 to 4  $R_E$  only contains flux ropes that are lower in z and flowing towards the flanks.*

Line 341: Consider using “convected” instead of “adverted.” Same for other places.  
*This will be rephrased.*

Line 390: Clarify the term “one-dimensional axis.”

*The axis is a one-dimensional line, as opposed to the three-dimensional volume of a flux rope. This will be rephrased to be clearer.*

Line 392: Explain the use of “said.”  
*This will be rephrased.*

Line 434: Revise “priori” to “prior” or “previously.”  
*This will be revised.*

Line 437: Clarify the term “agnostic.”  
*This will be rephrased.*

Line 441: Consider using “antiparallel” instead of “shearing.”  
*This will be corrected.*

Line 443: Revise “shear component” to “antiparallel component.”  
*This will be revised.*

Line 444: Consider using “property” instead of “integrity.”  
*This will be changed.*

Line 447: I think that with Vlasiator simulations, it is also possible to investigate the energizations of protons and electrons as well as the important of flux transfer events in transferring magnetic flux and particles in the space

plasma physics (Section 2.1 in Sun et al., 2012, <https://doi.org/10.1007/s11430-021-9828-0>).

*We fully agree and this will be added.*