We would like to thank the reviewer for his/her help to review our paper. The comments and suggestions are encouraging and useful in revising the manuscript. We have responded to the reviewer's comments below.

Summary

The manuscript reports experimental observations made by the BepiColombo mission during an Earth flyby on 10 April 2020. It focusses on the crossing of the Earth's magnetopause, and uses data from the MPO magnetometer and MMO electron spectrometer. A series of flux ropes are identified in the data, and their qualitative motion is compared with models of the expected X-line location, showing good agreement. A flux rope model is also used to calculate various properties. Evidence is presented showing that one flux rope in facts consists of two discrete structures separated by a thin current sheet, and it is argued that coalescence via magnetic reconnection is occurring.

Overall the manuscript makes a new and important contribution to our knowledge and understanding of flux ropes on the Earth's magnetopause and subject to minor corrections I would recommend publication. This is based on a need to clarify certain aspects of the analysis, and also soften some of the statements, particularly on the existence or otherwise of active reconnection at the thin current sheet seen in the proposed coalescence structure. The comments below expand on this in more detail, and are presented in the order they appear in the manuscript. In addition I would also recommend a careful proof-reading of the manuscript to address some mistakes in English and grammar which I have not listed.

Detailed comments

Line 35. A caveat to this paragraph is that the transport of flux means they are closed to the ionosphere at one end.

We agree. We have added a sentence here to emphasize this point.

"The FTEs usually include magnetic field lines with one end connecting to the solar wind and the other to the cusp. They contribute to the transport of magnetic flux from the dayside to the nightside magnetosphere that drives the Dungey cycle in dipolar planetary magnetospheres."

Line 49. It would be worth citing recent studies on this topic by e.g. Toledo Redondo et al. https://doi.org/10.1029/2021JA029506

We have cited this newly published paper.

Line 57. I am not sure it is not quite right to say that e.g. Oieroset et al. and Kacem et al. observed coalescence of flux ropes. There is so-called secondary reconnection, but the analysis suggests it is of a type where interlinked flux tubes are in tension against each other and then reconnecting.

The reviewer is correct. We have rewritten this place to include some detail information.

"NASA's Magnetospheric Multiscale (MMS) Mission (Burch et al., 2016) has provided several observations of secondary reconnections between neighboring flux ropes (see, Zhou et al., 2017), between the flux rope and Earth's dipole magnetic field (Poh et al., 2019), and between interlinked flux tubes (Øieroset et al., 2016; Kacem et al., 2018)."

Line 70. Add a comment to mention that MMO and MPO are attached and so for the purposes of the flyby there is one spacecraft/observation point.

Thanks for the suggestion. We have added "The MPO and the MMO were attached during the Earth flyby. Therefore, their measurements could be deemed as one observation point during the Earth flyby."

Line 80. Maybe mention the local time here, or the exact location in GSE

We have added the exact location in this place, which is (11.2, -4.8, -0.3) R_E in the GSM coordinate.

Line 101. In the overview figure it may help to plot the magnetic field in the boundary normal coordinate system as well. This would help show the existence of the flux ropes even more clearly, and allows the reader to see the polarity in B_N (negative/positive for southward and positive/negative for northward) more clearly.

In Figure 1, we have added the magnetic field component normal to the magnetopause B_N (Figure 1d).

Line 126. The location of the model X-line in Figure 2a is nicely consistent with the observations, but I found Figure 2b and 2c harder to understand. In Figure 2c there is no predicted X-line? In Figure 2b it is highly tilted, and so while I agree that it would lead to northward motion in the general sense, there would also presumably be lateral motion with the reconnection exhausts pointing northward and dawnward. This should be clarified.

Figure 2c corresponds to a very strong IMF B_x ($B_x/B > 0.90$). Under this situation, a continuous X-line along the maximum magnetic shear location is very difficult to draw. Since IMF field line would drape over the magnetopause under such a large Bx, and we are still missing a comprehensive study on how the IMF draping works. Therefore, we did not draw a predicted X-line for Figure 2c.

However, as outlined in Trattner et al. [2007], large IMF Bx cases seem to settle for a magnetic reconnection location in the antiparallel reconnection sites (white areas in Figure 2). The reconnection site in Figure 2c is therefore predicted to be in the white areas of the magnetopause magnetic shear angle plot which is – with respect to the satellite location at the magnetopause and associated observations - similar to the location outlined in Figure 2b.

This has been clarified in the revised manuscript.

Yes. We agree with the lateral motion of the reconnection exhaust. We have clarified this in the revised manuscript.

Line 142. Is it necessary to assume a specific speed for the fit, or just that it is moving at constant speed? I could understand that the speed is necessary to get the estimate of flux content.

The fitting does not require a background speed. To obtain the scale and flux content, we need a background speed for the FTE-type flux ropes.

This has been clarified in the revised manuscript.

Line 149. The model gives interesting extra information about the flattening of the flux ropes. Apologies if I missed this, but can you add some text to discuss how the flux ropes are flattened, is it in the direction of motion, or along the normal to the current sheet. Also is the flattening significant? Is there much deviation from a circular profile. I think these points would be of interest to other readers studying this problem.

We have added further explanations of the flatten profile of the flux ropes. "The semi-major corresponds to the scale of flux rope along with $\vec{n}_{min}$, which is close to L direction of the magnetopause. The semi-minor correspond to the scale of flux rope along with $\vec{n}_{max}$, which is close to the N direction of the magnetopause."

In Table 1, the column of scale has been added a ratio of semi-minor to semi-major. In the text, we have added the following descriptions.

"the flux ropes centered at 00:26:06 UT, 00:26:26 UT, and 00:30:26 UT, are close to circular profiles with the semi-minor slightly smaller than the semi-major. The flux rope centered at ~ 00:28:13 UT includes the strongest flatten profile."

Line 166. This is a very nice observation. For completeness, are you able to model FR#A and FR#B independently – is it possible to say anything about how well aligned they are?

We have tried to model FR#A and FR#B separately, but we did not obtain reasonable results. Therefore, we have further analyzed the results from the MVA technique. The applications of MVA on FR#A and FR#B.

FR#A (00:28:03 to 00:28:09), $\lambda_{max}/\lambda_{int}$ ~ 1.91, $\lambda_{int}/\lambda_{min}$ ~ 21.7, $\vec{n}_{min}$= [-0.20,-0.58,-0.79]

FR#B (00:28:09 to 00:28:16), $\lambda_{max}/\lambda_{int}$ ~ 3.34, $\lambda_{int}/\lambda_{min}$ ~ 12.6, $\vec{n}_{min}$= [0.23,-0.55,-0.80]

Only the $\vec{n}_{min}$ are well determined in both cases, which are close to each other with a separation angle of 25°.

The $\vec{n}_{min}$ obtained for the whole coalescence event is [-0.04,-0.49,-0.87], which are 12° and 17° away from the $\vec{n}_{min}$ of FR#A and FR#B separately.

We believe that the small separations of the $\vec{n}_{min}$ between the FR#A and FR#B shall indicate they are well aligned. We have added some explanations of these results in the revised manuscript.

Line 178. The existence of the thin current sheet separating the two flux ropes is clear and therefore a site where reconnection can occur. But I think the statements should be softened a bit here, because on the basis of the data alone, it is not 100% certain that reconnection is occurring, as there is no complementary evidence. I know that jets cannot be observed, but is there any evidence for e.g. Hall magnetic field signatures or other structure that would point to active reconnection ongoing? With a guide field of 0.28 this signature would be somewhat distorted but should be visible, and could be related to the more-negative deviation in B_M

where B_L reverses. In the electron data is there any evidence for localised heating etc. (although this would likely be a weak signature and maybe difficult to observe in the 4s cadence data)? Also is it possible to use the electron data to understand the connectivity of the plasma through the whole observation of FR#A and FR#B.

We agree with point. Yes. It is hard to certain that reconnection is occurring without complementary evidence.

We did not see clear Hall magnetic field signatures even with a large guide field. The B_{int} in Figure 4b did not become more negative but less negative when B_{max} reversed. We think that this could be due to either the spacecraft crossed the center of reconnection X-line or the reconnection did not occur.

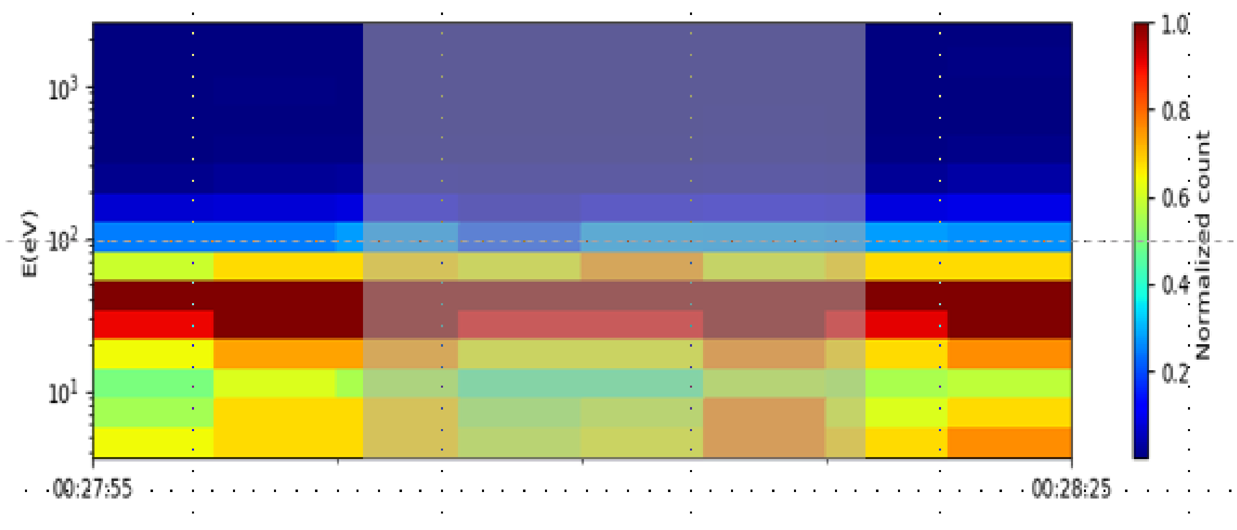

Figure A.

In this figure, we have provided the low-energy electron measurements associated with the coalescence event. The shaded region include the flux ropes.

During cruise phase including planetary flybys, the Mio spacecraft needs to be shielded by its Sunshield (MOSIF), and so the measurements of Mio/MEA are limited in field of view. We cannot obtain a complete distribution of electrons relative to the background magnetic field. Therefore, it is difficult to obtain further information from the low energy electron measurements as well.

In conclusion, we agree with the reviewer to soften our conclusion about the secondary magnetic reconnection. We have added more discussions in the manuscript.