General remarks

Wang et al. investigated the roles of electrons and ions in the formation of the current in the mirror mode structures in the plasma sheet using by the MMS observations. They found that the electrons and ions play a different role in the different sizes of mirror mode structures: the current carriers are mainly the electrons in small size mirror mode by magnetic gradient-curvature drift, and the ions in large size mirror mode by the ion diamagnetic drift. This study sheds new light on formation of currents in the mirror modes, and is worthy of publication in AG after moderate reversion.

In the discussion section: MMS consists of four identical spacecraft, and could provide the simultaneous measurements of four points. Why the authors use the plasma measurements and magnetic field to estimate the time series of magnetic gradient curvature drift, electron diamagnetic drift, ion diamagnetic drift, and other terms. I think this is useful to estimate these different terms and then compare them.

Line 18 It would be better to replace "data" to "instruments", or remove "data".

Answer: Thanks for your nice suggestions. We have removed "data" from this sentence.

Line 47-49 Actually the sizes of magnetic holes can be less than ion cyclotron radius in the magnetosheath. Such magnetic holes, named as kinetic-size magnetic hole or electron vortex magnetic hole, are widely observed using by MMS (doi:10.3847/1538-4357/ab0f2f, doi:10.1002/2017JA024415, doi.org/10.3847/1538-4357/aac831, doi:10.1002/2016JA023858).

Answer: Thanks for your comments. "Magnetic holes with a scale less than 1 ρ_i also exist in the magnetosheath as well as in the plasma sheet, and electron vortices are found inside these kinetic-size structures (Huang et al., 2017, 2018, 2019; Yao et al., 2017)." We have added these sentences in our revised manuscript.

Line 54-56 The small-size magnetic holes, below one ion cyclotron radius, are also detected in the plasma sheet (doi.org/10.3847/1538-4357/ab0f2f). These magnetic holes are always accompanied with electron scale instabilities, such as whistler waves.

Answer: Thanks for your comments. “Magnetic holes with a scale less than 1 ρ_i also exist in the magnetosheath as well as in the plasma sheet, and electron vortices are found inside these kinetic-size structures (Huang et al., 2017, 2018, 2019; Yao et al., 2017).” “Mirror mode structures accompanied by electron dynamics and whistler waves are also reported to occur during the dipolarization processes (Li et al., 2014; Huang et al., 2018).” We have added these sentences in our introduction.

Line 61-63 Dipolarization fronts are widely investigate in many literatures (doi:Âa10.1002/2015JA021083, doi:10.1029/2012GL051784, doi:10.5194/angeo-30-97-2012), and they play an important role in the energy conversion, mass transport, particle accelerations, and wave activities.

Answer: Thanks for your comments. “Dipolarization fronts (DFs), characterized by a sharp enhancement in B_Z in GSM, are formed ahead of the earthward fast flows (Ge et al., 2012; Wu et al., 2013; Schmid et al., 2016; Xiao et al., 2017). They play an important role in the energy conversion, mass transport, particle accelerations and wave activities (Fu et al., 2012; Huang et al., 2012, 2015).” We have added these sentences in our introduction.

Line 72-75: I suggest the author give the motivation of this paper to help the readers to better understand their work.

Answer: Thanks for your nice suggestion. “Our aim is to figure out whether the main contributor to the current inside the ion-scale mirror mode structure is the electron or ion.” We have added this sentence to the last paragraph of the introduction.

Line 80-83 (Russell et al., 2014) should be corrected to (Russell et al., 2016). If the author did not use the burst mode data in this paper, I suggest the authors remove the introduction about the resolution of burst mode in this part.

Answer: Thanks for your suggestions and comments. We have made correction to the reference. We have also deleted the description about the burst mode data in the introduction.

Line 115-117 Why are the data performed low-pass filtered before the timing analysis? I suggest the authors give some descriptions here.

Answer: Thanks for your nice suggestions. Waves with a period of several to ~20 s can be found inside the magnetic dip in Figure 3. To reduce the effect of high frequency fluctuations, the data have been performed low-pass filtered before the timing analysis. We have given descriptions in our revised manuscript.

Line 120 “tends to be larger” “increases” or “has a peak”?

Answer: Thanks for your comments. We meant that the ion number density has a peak in the trough of the oscillations. To better descript the relation between the number density and the total magnetic field, we have changed this sentence to “The total magnetic field varies in anti-phase with the ion number density during this interval.”

Line 131: how to calculate the local ion gyro radius? Which time interval? Please give the details in the text.

Answer: Thanks for your comments and suggestions. The local ion gyro radius is calculated by the average ion perpendicular temperature and the average magnetic field magnitude between 20:51:55 – 20:52:56 UT. We have given more details in our revised manuscript.

133-135 Why the range of the scale and the angle are inconsistent with those in table 1? The "rotation angle" is the "shear angle"?

Answer: Thanks for your comments. The angle is the angle between the magnetic field directions at two edges of each structure. The inconsistency here is caused by a typo. We have revised it in our manuscript. Since we mainly focus on the first and last mirror mode structures, and the information in table 1 can be found in the text, so table 1 is not necessary now and we have deleted it in our revised manuscript.

Line 155: As the authors know, the separation of the four MMS spacecraft is very small. Thus, one can use the curlometer method to estimate the current density based on the magnetic field from four spacecraft. Why not the author use this method to calculate the current and compare with the current derived from the plasma measurements?

Answer: Thanks for your comments and suggestions. The current density can be determined by the plasma moments or the curlometer method. To study the relation between ions/electrons and the current density, the current density calculated by the curlometer method is a better choice. So, we calculated the current by the curlometer in our revised manuscript. And we compared the current with the electron/ion velocity, and found a strong relationship between the current and the electron or ion velocity.

Line 192 J_N should be corrected to J_M.

Answer: Thanks for your comments. We have revised it in our manuscript.

Line 216: "Ion velocities" should be "Ion velocities Vi_md"?

Answer: Thanks for your comments. We have revised it in our manuscript.

Line 230-235 The pileup region usually exists behind the DFs, not ahead of the DFs, for example the definition of flux pileup region in the paper (doi:10.1029/2012JA018141). In addition, the mirror mode structures are observed after the detection of DF. Why the authors thought they originate from the pileup region ahead of the DF?

Answer: Thanks for your suggestions. Yes, the flux pileup region usually occurs behind the DF, and the region ahead of the DF is called the pressure pileup region. I have changed “the pileup region” to “the pressure pileup region”.

Since mirror mode structures are stationary in the ambient flow, we can estimate the distance of the structures relative to the DF in the Y direction using the average V_Y ~30 km/s during the structures. Thus, they are likely to occur dawnside of the MMS spacecraft with a distance of ~4 R_E in the Y direction when the spacecraft are crossing the DF at around 20:38 UT. Compared this distance with the typical size of the DF (~3 R_E) (Huang et al., 2015) and the size of the structures, the mirror mode structures might come from the dawnside flank of the DF. Since the DF is considered to be a tangential discontinuity (Schmid et al., 2019) which pushes the background plasma to its flanks (Fu et al., 2012a, 2012b; Liu et al., 2013; Birn et al., 2015), the plasma near the flank is expected to come from the pressure pileup region ahead of DFs. In addition, mirror mode structures have been reported to be potentially generated in such a pressure pileup region (Zieger et al., 2011; Wang et al., 2016). Thus, the mirror mode structures in Figure 1 might originate from the pressure pileup region ahead of the DF.

Line 243 Please indicate at which time “The amplitude of the bipolar j_N in MM1 is ~2 nA/m^2”.

Answer: Thanks for your suggestions. We have added the time interval in this sentence.

Line 247 It would be better to add “in MM5” after “electron velocity”

Answer: Thanks for your suggestion. We have revised it based on your suggestion.

Line 271-272 The authors can try to use the magnetic field from four MMS spacecraft to estimate the curvature radius of mirror modes.

Answer: Thanks for your suggestion. Using the data from all four MMS satellites, we can determine the curvature of MM1 by

$$\rho_c = B^{-2}B_i\nabla_i B_j - B^{-4}B_j B_i B_l \nabla_i B_l$$

where the indices i, j and l indicates the three components of the magnetic field, and B = |B| (Shen et al., 2003). The curvature radius R_C is $1/\rho_c$. We have estimated the curvature radius of the mirror mode structures, and discussed it in our revised manuscript.

Line 286-187 Did the authors ever calculate the magnetic gradient drift velocity in MM5? It would be necessary to compare the magnetic gradient drift velocity and the Vi_N.

Answer: Thanks for your suggestion. We use the data in the time interval between 21:02:30 and 21:02:50 UT to estimate the ion thermal pressure and magnetic gradients. Also, the average ion perpendicular and parallel temperatures, average total magnetic field and average curvature radius in this interval are used to estimate the velocities of the ion drift motions. Consequently, the velocities of the ion diamagnetic, magnetic gradient and curvature drift motions are ~17 km/s, 33 km/s and 79 km/s, respectively. Since the ion diamagnetic and magnetic curvature drifts move almost in the same direction in the M-N plane, while the ion magnetic gradient drift moves in the opposite direction. Thus, the collective drift velocity is ~63 km/s, very close to the ion velocity inside MM2 (which is MM5 in our previous manuscript) with a speed of 70 km/s.

Line 304-307 Did the authors compare the normal directions calculated by MVA and timing method to ensure the accuracy of the results.

Answer: Thanks for your suggestion. Comparing the normal directions determined by MVA and timing method can ensure the accuracy of the results. However, no burst magnetic field data are available in this time interval. So, we did not compare the normal directions calculated by both methods in our manuscript.

Line 307-309 Please indicate which MMS? 1 or 2 or 3 or 4 after "trajectory of MMS". How to deduce the possible trajectory of MMS, please give details in the text.

Answer: Thanks for your comments and suggestions. Since the inter-spacecraft distances of MMS are very small compared to the scale of this mirror mode structure, the trajectory of the four MMS satellites are almost the same. Therefore, we only draw the trajectory of MMS1 in this figure. Based on the studies about the geometry of the mirror mode structure, we assume that the cross-section of the mirror mode structure is a circle. According to the normal directions of the both half sides of the structure and the ambient flow direction, we can simply get the possible trajectory of MMS1. We have added these details in our revised manuscript.

Line 316 Please add a color bar in Figure 5.

Answer: Thanks for your suggestion. We have added a color bar in this Figure.