1. Mirror mode waves are generated by ion temperature anisotropies and usually identified by combining magnetic and ion observations. As shown by previous studies (Song 1994, Ruhunusiri 2015, Fraenz 2017, see below) most ULF waves in the Earth, Mars and Venus magnetosheaths are of Alfvenic type. ULF waves without field rotation are largely of fast Alfvenic type and only a small percentage are of mirror mode type. When using only a magnetic criterion one would expect that what is called 'mirror-mode-like' in the present study identifies mainly fast Alfvenic waves. Thus the term 'mirror-mode-like' is rather misleading.

2. Why mirror mode occurrence should depend on solar activity is not clear. The proposed dependence on pick-up of exospheric ions is rather speculative. If this would rearly be the case a comparison between the occcurrence in Venus and Earth magnetosheath should be done. Since at magnetosheath location at Earth pick-up is very small a clear difference to Venus and Mars should be observed. More important than the pick-up could be the bow shock normal angle dependenece for the plasma downstream of the shock.

In conclusion I recommend a major revision of the paper where

1. the results are discussed in relation to the more robust studies by (Song 1994, Ruhunusiri 2015, Fraenz 2017) and the term 'MM-like' should probably be replaced by fast Alfvenic.

We will extend the discussion with the references given by the referee. However, we do not think that replacing "MM-like" with "fast Alfvénic" is appropriate.

2. the physical influence of the pick-up process should be better proven or justified why it should have major influence only just behind the bow shock.

Naturally, an increased number of pick-up ions will not only have an effect just behind the bow shock. Delva et al. (2015) found an increase in cyclotron wave detections by a factor 3, caused mainly by an increased ion pick-up. It could be expected that this also has an influence on the generation of MMs in the magnetosheath. Indeed, we find that there is a small effect in the magnetosheath, with the probability of detecting MMs during solar maximum is 60% higher than for solar minimum.

Minor comments by line number:

32: it should be stressed that the theory of MMs usually only considers the ion temperature since the instability evolves on ion scales. The role of the electron temperature in this is less clear.

Eq. (1) shows the instability criterion for a plasma with all species i which include also the electrons. It has been shown, lately, that for small scale scale magnetic holes the electron vortex plays an important role (e.g. Wang et al., 2020). In order to investigate the effect of the electrons in Eq. (1) in Venus's magnetosheath, one would need the electron data from the ASPERA-ELS sensor. Fränz et al. (2017) show data from ELS where the electron time-energy plot gives an upper value of ~100 eV for the energy of the electrons in the magnetosheath and the density is of the order of ~10 cm-3. This can be used in comparing the influence of electrons as compared to the ions, under specific assumptions for the electrons (Tpar, Tperp).

50: it should be mentioned here which processes are relevant in the Venus magnetosheath.

Indeed, there was a part missing here. The paragraph should read:

The first process will occur mainly in the solar wind interaction with the planetary exosphere (with the exception of Jupiter's magnetosphere and the Galilean moons, where the Jovian corotating magnetic field and magnetospheric plasma is taking the role of the solar wind) in the low-beta plasma case and generation of ion cyclotron waves will take place (Delva et al., 2008, 2009, 2011, 2015; Schmid et al., 2021). After crossing the quasi-perpendicular bow shock the anisotropy is increased, as is the plasma-beta and the MM instability will take over. The second process will occur mainly near the magnetic pile-up boundary where the magnetic field gets compressed and slowly increases in strength whilst getting closer to Venus.

63: maximum

corrected

66: completely ignored in this introduction is a series of papers which analysis ULF plasma wave types using both magnetometer and ion spectrometer data and thus has a superior wave type identification:

Song, Russell, Gary, JGR, 99,6011 (1994): Identification of low-frequency fluctuations in the terrestrial magnetosheath.

Ruhunusiri et al. GRL, DOI: 10.1002/2015GL064968 (2015): Low-frequency waves in the Martian magnetosphere and their response to upstream solar wind driving conditions

Fraenz et al., PSS, DOI: 10.1016/j.pss.2017.08.011 (2017): Ultra low frequency waves at Venus: Observations by the Venus Express spacecraft

Specifically the last paper applies the Song-Russell method to VEX magnetometer and ASPERA-4 ion and electron data to obtain a statistical wave type identification. Here the high temporal resolution (4s) of the electron spectrometer is used to obtain properties of the ion distribution under the assumption quasi-neutrality.

By this method the authors show that ULF waves of mirror mode type at the dayside of Venus occur only close to the MPB with a share of about 15% of all ULF wave types. We regard these results as much more robust than the results presented in the current manusccript.

The identification paper by Song et al. is an important method for identifying wave modes when one has a full set of plasma measurements at the appropriate sampling rate. This paper will be presented in the introduction, and then a reasoning will be given why we turned to the Lucek et al. method, because of missing plasma data at an appropriate resolution. Indeed, in the Fraenz et al. paper uses Venus Express ASPERA-4 ELS data to get a grip on the plasma characteristics, with various assumptions. There are some critical points in this method, e.g. the resampling of the data to 4 s resolution (to fit B and Ne), and it is not clear how this works out on the MVA, and the crude resolution used in Fourier analysis in 128 s windows may well fail to detect structures.
However, as mentioned above already, the robustness of the method used in this paper has been shown by other studies. Indeed, comparing the numbers in Fig. 6 middle panel one can see that the occurrence rates are actually less for the current study (<= 10%) than for the Fränz et al. study (~20 %).

Finally, it should also be mentioned that the Song-scheme has also been criticized many timed (e.g. Schwartz et al. 1996, Denton et al. 1998, and Sahraoui et al. 2003). Naturally, a qualitative comparison with the results from Fraenz et al. should be made, but quantitative comparison will be difficult because of the highly different detection methods.

75: yes, it is doubtful whether ASPERA-4 IMA data alone with 192s resolution and restricted field of view can be used in this context. Faenz et al. 2017 try to overcome this problem.

Indeed, the resolution of ASPERA-4 IMA is not enough to use for wave identification. We have now obtained the ASPERA-4 ELS data from Markus Fränz and can check with these the density variations for selected events.

85: Simon Wedlund (2022a) discusses that the identification of MM-like structures based on magnetometer data alone does not make much sense.

We think that the discussion by Simon Wedlund et al. (2022a) is more nuanced than the referee makes it sound. In that paper it is actually shown that the B-field only determination works well, checked later by using the plasma data on the MAVEN spacecraft. A further discussion of the validity of this method is given in Simon Wedlund et al. (2022b, Paper 1).

100: a bow shock model based on VEX observations was derived by Martinecz et al., JGR, DOI: 10.1029/2008JE003174 (2009) and later improved by Chai et al., JGR, DOI: 10.1002/2014JA19878 (2014).

Indeed, there are other bow shock models that can be used, as these two mentioned by the referee. We will mention these models in the paper.

113: section reference missing.

LaTeX typo

Figure.2: variation direction: It would be more interestin to see examples which also show MPB crossings because closer to the MPB usually more MM structures can be identified.

New examples will be added to the paper. Indeed, MMs near the MPB should also be shown, this was an omission in the paper.

The conclusion of this section seems to be that the CSW method is more accurate.

142: the definition of VSO is incorrect: Z_VSO points to Venus orbital North, not 'solar North'. It is not clear why the division into solar min and maximum is made. Physically it would make more sense to divide into observation behind a quasi-parallel and quasi-perpendicular bow shock.

Correct, Venus north and not solar north, this will be corrected.
The reason for looking at solar minimum and maximum has been discussed above already. However, the referee is correct that the effect of quasi perpendicular and parallel bow shock conditions should be more important, as shown e.g. in Volwerk et al. (2008b). The data have already been reprocessed with the predictor-estimator method for the bow shock location (Simon Wedlund et al., 2022a), where also the condition of the bow shock is determined. This will be analysed in the revised version of the paper.

155: it is confusing to discuss Fig. 7&8 at this point while they appear much later in the paper.

This is an editing error, after adding figures 4 and 5, these figures shifted down. They will be moved up again.

170: since no temperature data are used in this analysis the conclusion is pure speculation. If you compare with results by Fraenz 2017 it is found that the 'MM-like' structure behind the bow shock are just fast alfvenic waves.

We disagree, see discussion above about the detection methods.

190: also this discussion indicates that a separation of the data set according to upstream bow shock type would make more sense. The expansion of the exosphere during solar maximum causes mainly more ICWs.

See above.

202: is there any conclusion from Figs. 4&5? Otherwise they can also be omitted.

These figures show the various distributions of the characteristics of the MMs. A further discussion will be added to the paper.

Figure 6: what is the reference for the MPB or ionopause location?

The MP/Ionopause model is from Zhang et al. [2007]. The omitted reference will be added in the paper.

226: it is not clear why pick-up production should be higher just behind the bow shock. The hydrogen exosphere has an exponential fall in density independent of the bow shock.

Discussed above.

274: show

Corrected