



EGUsphere, referee comment RC2  
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## **Comment on egusphere-2022-645**

Anonymous Referee #2

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Referee comment on "Statistical distribution of mirror mode-like structures in the magnetosheaths of unmagnetised planets: 2. Venus as observed by the Venus Express spacecraft" by Martin Volwerk et al., EGU sphere,  
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Review of manuscript:  
Statistical distribution of mirror mode-like structures in the magnetosheaths of unmagnetised planets:  
2. Venus as observed by the Venus Express spacecraft  
submitted to Ann.Geophys. August 2022 by M.Volwerk et al.

General verdict:  
This manuscript describes an extended analysis of low frequency wave structures (ULF) observed in the Venus magnetosheath by the Venus Express magnetometer. The analysis tries to identify structures of a type which they call 'mirror-mode-like'.

The paper is an extension of a previous study by the same authors (Volwerk et al. 2016) discussing mainly the occurrence rate of MM-like structure in dependence on solar activity. The main difference compared to the earlier study is that the data set has been extended and a comparison with a study on ion temperature observations by Rojas-Mata et al. (2022) is given. Thus the present paper contains some new material though conclusions are similar to the previous publication. I have two main points of critique on the method of the paper:

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 Alfvénic type. ULF waves without field rotation are largely of fast Alfvénic 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 Alfvénic 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 really be the case a comparison between the occurrence 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 dependence 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 Alfvénic.
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.

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.

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

63: maximum

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 manuscript.

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.

85: Simon Wedlund(2022a) discusses that the identification of MM-like structures based on magnetometer data alone

does not make much sense.

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).

113: section reference missing.

Figure.2: variation direction

It would be more interesting to see examples which also show MPB crossings because closer to the MPB usually

more MM structures can be identified.

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.

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

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 alfvénic waves.

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.

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

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

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.

274: show