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Interactive comment on "Observational support for the electron mirror mode: AMPTE-IRM and Equator-S measurements in the magnetosheath" *by* Rudolf A. Treumann and Wolfgang Baumjohann

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1. I find the observations far from convincing. There is no confirmatory plasma data showing that the plasma pressure is out of phase with the magnetic pressure.

We have explicitly said, already in the original submission, that there were no plasma data in Eq-S. This had been mentioned already in Baumjohann et al 1999, and before in Lucek et al. 1998a,b to which we refer. In particular Lucek et al. have given unambiguous proof, using other arguments and observations, that the large amplitude magnetic oscillations were (ion-) mirror modes. In fact, of the sequence used in Lucek, the 1999 paper by Baumjohann took a short exerpt at high resolution (128 Hz) to demonstrate

the observation of lion roars at the bottom of the mirror troughs where the whistlers could marginally be resolved as oscillations in the magnetic field. The magnetic time resolution would, however, not be sufficient to resolve the higher frequency whistlers. All earlier observations of lion roars (see the literature) were not based on magnetic but on wave observations like in our figure 1.

What concerns AMPTE IRM, there is no need anymore to prove pressure balance. AMPTE IRM had a large record of ion mirror modes in confirmed pressure balance. The 6 min sequence shown in Fig 1 is long enough as belonging to the family of mirrors. In order to show what the reviewer demands, we nevertheless added a new figure showing plasma and magnetic data from AMPTE IRM over 6 min where the anti-correlation between ion mirror modes and plasma (density, temperature) is obvious. Three cases are indicated by shading. We dare to overload the paper with more of this.

We have also given the time resolutions. The reviewer might realize that the time resolution of 4 s spin for AMPTE IRM inhibits a clearer one-to-one anti-correlation. It could be done better statistically but for our purposes it suffices to show that there is anti-correlation. Nature was so unkind not to align the spin with the magnetic field in the mirrors such that there are only single cases which at the available spin resolution of the plasma data exhibit the anti-correlation.

What concerns Eq-S, the mirror waves shown are a high resolution 128 Hz exerpt from the full lower resolution sequences in Lucek et al. where it was shown that these are mirror modes even though no plasma data were available. Would they have been available, they could at 3 s time resolution be used marginally for demonstrating pressure balance in the ion mirror modes, but there would have been no chance to demonstrate the pressure balance in the electron mirrors. Thus the demand of the referee could anyway not have been satisfied and is in fact malevolent. All the relevant references which have published thes numbers, in order to satisfy the reviewer, have been added. We are sorry, but we do not have better examples from those measurements in this time resolution in particular as those data have not survived or are not anymore readable from old tapes.

2. The authors have also not addressed why the electron anisotropy would not be absorbed by the electromagnetic whistler mode “lion roars” instead of by the electron mirror mode instability. Thus from a theoretical point of view, electron mirror modes would not be expected.

We are surprised! The text of the review suggests that the reviewer is not a beginner but firm in both observation and theory. However, he still is subject to the typical misunderstanding of the role of anisotropy.

In fact, the anisotropy driving any mirror modes is a fluid-macroscopic anisotropy. That which excites whistlers is the anisotropy of a small group of higher energy resonant trapped particles. The reviewer should consult Kennel and Petschek 1966 where this was quite clearly expressed. But the reviewer is excused because this misunderstanding is widely spread.

Whistlers live on the anisotropy of the energetic resonant particles (radiation belt electrons, for instance). Depletion of this anisotropy does by no means affect any possible macroscopic temperature anisotropy which drives mirror modes. For the depletion of the latter the temperature of the bulk must be changed, which the resonant particles are unable to do. They are just a few and don’t do nothing on the macroscopic anisotropy.

The large 50% ion mirror amplitudes prove that depletion of anisotropy does not happen for the ion mirror mode anyway.

Lion roars are as well unable to do anything on the anisotropy which drives the electron mirror mode. Thus any quasilinear calculation misses the real effect which nobody has so far treated properly in theory. Noreen’s calculation (or our own earlier 1997 quasilinear treatment of the fluid ion-mirror mode) does not say anything in this respect. It just proves that quasilinear theory does not apply to any of the observed mirror modes

because all observations demonstrate that the amplitudes exceed the quasilinear level by far. This, however, is no argument against their (or earlier) linear calculations which can be used and give reasonable results.

Concerning the references, we have included the suggestions (and a bunch of others more). Thanks for alerting us.

Needless to say that we have introduced a substantial number of explanations in the text (all in blue), added two figures: fig 2 showing the anticorrelation magnetic-plasma in AMPTE IRM, fig 4 a blow up of some regions where indications of high-frequency whistlers (lion roars) are evident from the Eq-S magnetic field trace noting that these cannot be resolved by the 128 Hz magnetic resolution which just marginally sufficed to resolve the lowest whistler frequencies at the bottom of the ion-mirror modes in Baumjohann et al 1999. The wave observations of AMPTE IRM show clear indiations of the presence of all those whistlers.

Finally, we changed the title of the paper in order to accommodate the doubts of this reviewer, since our observations and discussion is reasonable but is no direct observational proof. Some other possibilities still exist which me mention in the paper. One would be electromagnetic ion-cyclotron waves (ion whistlers) in weak kinetic turbulence which could be mistaken as electron mirrors though we argue against that possibility. We have indicated this caveat in the text. The other are short wavelength drift modes which we cannot exclude but also cannot identify. Any proper weak kinetic turbulence of ion mirror modes should identify and account for those short wavelength eletromagnetic drift waves and ion-whistlers excited in the plasma and magnetic pressure gradients inside mirror modes. These waves grow on timescales much faster than the quasilinear mirror saturation scale such that quasilinear depletion does not come into effect and the mirror mode can reach the observed large amplitudes.

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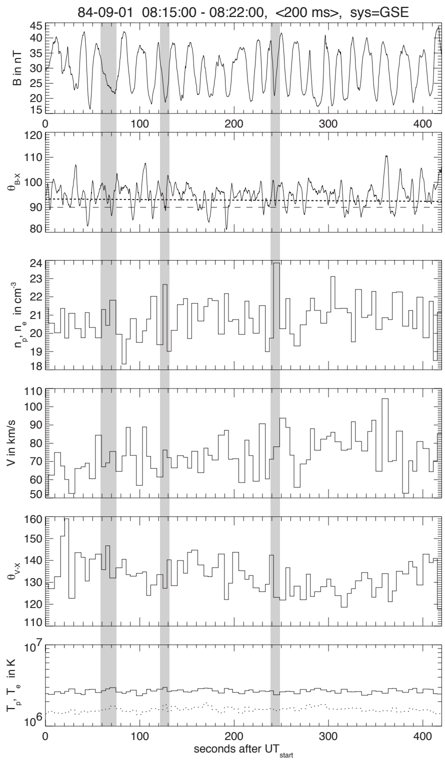

Fig. 1. 6 min ampte irm plasma and magnetic field showing the anti-correlation in ion mirror modes