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## Comment on angeo-2021-68

Anonymous Referee #1

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Referee comment on "High bandwidth measurements of auroral Langmuir waves with multiple antennas" by Chrystal Moser et al., Ann. Geophys. Discuss.,  
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Review of MS "High bandwidth measurements of auroral Langmuir waves with multiple antennas" by C. Moser, J. LaBelle, and I. H. Cairns

This manuscript describes the HIBAR rocket experiment. The manuscript very nicely describes the measurements of Langmuir/upper-hybrid wave fluctuations that coincide with the whistler/lower-hybrid wave fluctuations. Figure 2 displays two events where the high-frequency fluctuations are detected by the rocket. Figure 3 shows the corresponding low-frequency fluctuations (presumably with the wave angle quasi perpendicular to the ambient magnetic field, hence, interpreted as being associated with the lower-hybrid frequency cutoff). Figures 4 and 5 constitute the enhanced plots of the high-frequency spectrum, in particular, those cases that display the narrow Langmuir wave line and the so-called the diffuse spectrum. The manuscript devotes a significant portion on the discussion of the polarization of the measured electric field.

The authors present the analysis via Tables 1 and 2 where the readers may glean that the exact nature of the high-frequency fluctuations is uncertain. It appears that the main focus of Section 3 is on determining whether the measured high-frequency fluctuations are quasi-parallel Langmuir wave or quasi-perpendicular, or oblique, Z/upper-hybrid waves. If the authors can state this physical motivation at the very beginning of Section 3, then it would help readers understand the main thrust of Section 3 a bit more clearly. The authors do mention the motivation of this analysis, but almost at the end of Section 3, line 160, equations 1 & 2. It would be much more helpful for the readers if they mention the purpose of  $E_{\parallel}/E_{\perp}$  analysis at the beginning (in words) and rephrase in more quantitative details (through equations 1 & 2) at the end of Section 3, and further

elaborated in subsequent subsections (as they are laid out herein).

In subsection 3.1, the authors recapitulate the fundamental linear wave properties of plasma normal modes in over- and under-dense plasma. In subsection 3.2, they present the most interesting three-way analysis. Figure 7 appears to represent quite a sophisticated effort both in terms of extracting the necessary input parameters from data and also in terms of numerical effort. The authors make convincing argument that the three-wave processes involving the low-frequency whistler/lower-hybrid branch might be at work. The authors, however, point out that the model electron distribution function, shown in Figure 8, did not produce positive growth rate for the high-frequency waves corresponding to Figure 7, as evidenced from Figure 8c. The authors seem to have come to a conclusion that the free energy source for the high-frequency waves are the high energy electrons, but their instrument does not directly detect these particles.

One question that naturally arise is the following: In generating Figure 7 dispersion surfaces the authors have constructed the frequency,  $k_{||}$  and  $k_{\perp}$ . This means that the correspond  $E_{||}/E_{\perp}$  for the Langmuir and diffuse fluctuations can also be computed theoretically. How do they match up with observations, as laid out in the two Tables? are they consistent?

In the remaining part of Section 3, the authors discuss the wave intensities associated with the high- and low-frequency fluctuations and estimate the cumulative three-wave amplitudes involved in the decay process. However, this analysis is very speculative. Nevertheless, it might be useful for some future actual three-wave weak turbulence analytical calculation.

In conclusion, upon a careful reading of this manuscript my recommendation is to publish this work more or less in present form, but I suggest the authors to motivate Section 3 a bit more directly in the final version of their manuscript before publication, and to address the question I raised above.