Study of Langmuir turbulence and medium frequency auroral radio emissions

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Motivation

Medium frequency bursts (or MFBs) are a type of naturally occurring auroral radio emission whose generation mechanism is not well understood. A 2013 paper by Akbari et al. noted an apparent correlation between MFBs observed at Toolik Lake, Alaska, and electrostatic waves (Langmuir turbulence) observed in PFISR (Poker Flat Incoherent Scatter Radar) data. These electrostatic waves were seen as coherent echoes with flat ion-line spectra and double-peaked plasma-line spectra. Fig. 1 (from the same 2013 paper) shows the anomalous scattering event in the ion line power on the left and the MFB on the right. Akbari et al. 2013 only analyzed two such events, so this ongoing study acts as a follow-up to further investigate a possible correlation using many more events.

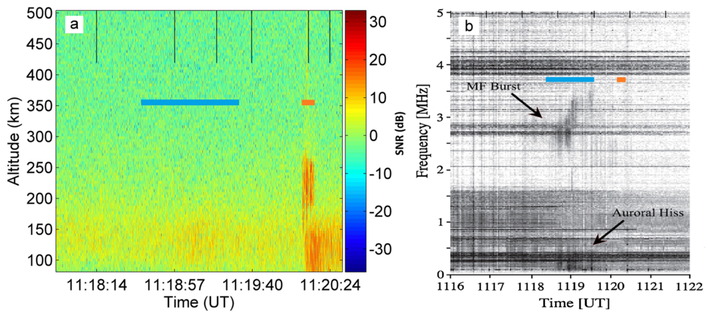


Fig. 1 (above): On the left is a plot from Akbari et al. 2013 showing the ion line power profile of coherent scatter. On the right is a spectrogram from Bunch et al. 2008 showing the associated MFB. The blue and orange bars, added by Akbari et al., show the same time intervals.

Fig. 2 (above): An image of the ground antennas at Toolik Lake in Alaska. Photo Credit: Nick Bunch.

Methodology

For this study, we combed through a database of MFBs observed at a ground station at Toolik Lake in Alaska (depicted in Fig. 2). The MFBs included in this study were from 2017 to 2019. We then requested PFISR radar data corresponding to the times of the MFBs and looked for anomalous scattering events. Corresponding radar data was available for 146 MFBs. Of those, 73 MFBs were associated with anomalous scatter. We then found that 8 of these 73 MFBs overlap exactly with the anomalous scattering events. We closely examined these coincident events, looking for fine structure correlation and for evidence that the anomalous scattering events may correspond to cavitating Langmuir turbulence (cavitons).

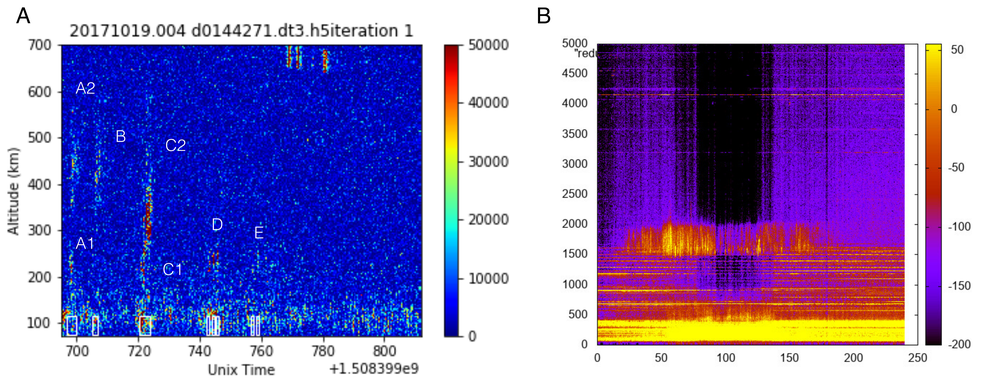
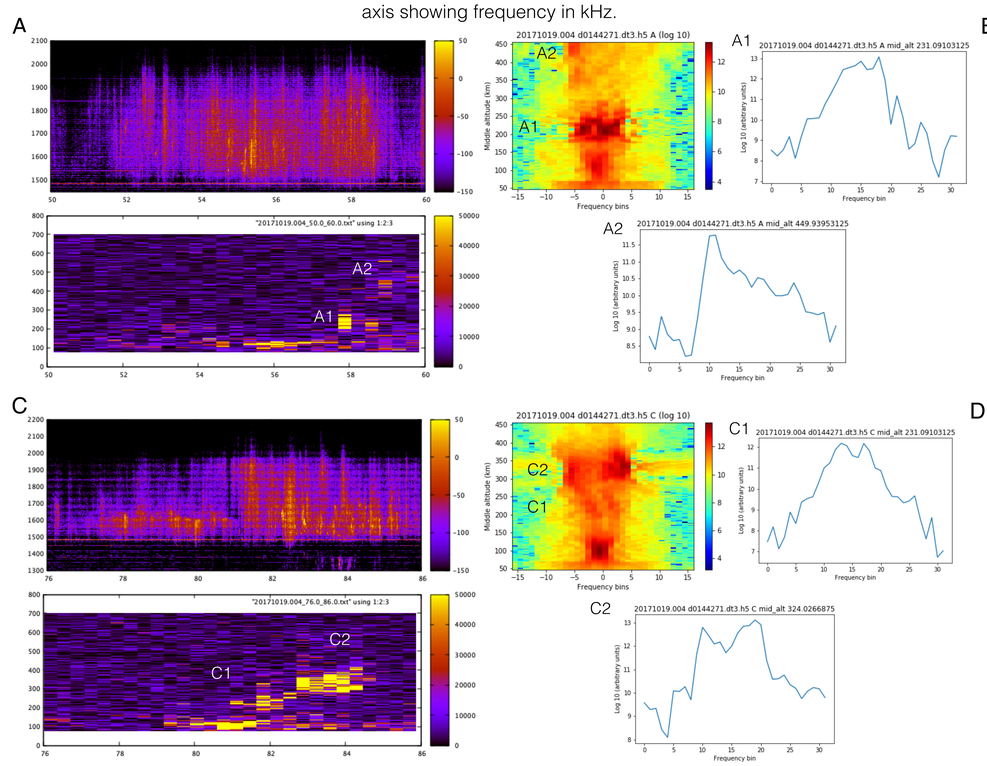


Fig. 3 (above): A) The ion line power plot for anomalous scattering events occurring on Oct. 19, 2017. B) A frequency spectrogram showing the MFB occurring on Oct. 19, 2017 with the x-axis denoting seconds since 7:54 UT and the y-axis showing frequency in kHz.



As an example, an MFB and coinciding anomalous scatter events from Oct. 19, 2017 are shown in Fig. 3.

To the left (Fig. 3A) is the ion line power plot for the Oct. 19, 2017 scattering events, with white boxes overlaid to show the time interval used to find the ion line spectra for each event. These spectra were used to search for features suggesting cavitating Langmuir turbulence. Fig. 3B shows the spectrogram of the coinciding MFB.

Below Fig. 3 are five two-panel plots corresponding to the five event groups in Fig. 3A, including expanded spectrograms and ion line power plots for the scattering events (as before, the x-axis denotes seconds since 7:54 UT). These show the detailed correlation between the the fine structure of the MFB and the anomalous scatter. Note in particular event C2, which is associated with anomalous MFB below the cyclotron frequency. To the side is the ion line spectra information.

Conclusion

We saw that for 146 MFBs, about 50% had anomalous scattering events occurring within about 2 hours and 16 minutes of the MFB. About 5% of the 146 MFBs had exactly coincident anomalous scattering events. For some of these, we observed interesting fine structure correlation. Further work is needed to confirm whether these anomalous scattering events are cavitating Langmuir turbulence.

References

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Bunch, N. L., LaBelle, J., Weatherwax, A. T., and Hughes, J. M. (2008), Auroral medium frequency burst radio emission associated with the 23 March 2007 THEMIS study substorm, *J. Geophys. Res.*, 113, A00C08, doi:10.1029/2008JA013503.

Acknowledgements

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