MMS Observations of a Foreshock Bubble with Waves Activities Related to Its Shock

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Part1 | Introduction



[Turner+2013]

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Recent works on foreshock bubbles

- Omidi et al. [2010] first reported foreshock bubbles (FBs), one type of large-scale foreshock transients, found in simulations.
- Three FBs observed by THEMIS were reported in Turner et al. [2013].
 Number Density & Memotic Field Lines
- FBs form due to interaction of rotational discontinuities with the backstreaming ions in the foreshock [Omidi et al., 2010].
 Liu et al. [2015] reported observations of tangential discontinuity-driven FBs.



[Turner+2013]

Of all 10 FBs observed by MMS, 7 had whistler precursor waves just upstream of their shocks. [Turner+2019]

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> Part2 | Overview of the foreshock bubble (FB)



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Properties of the FB observed by MMS

- MMS1 observed FB's core, with its deflected flows, depressed density and field magnitude, and increased temperatures, and then the shock.
- Spacecraft observed dispersed ions and energetic electrons were observed inside the core.

Properties of the upstream shock

- The shock velocity from Timing analysis $-193.6 \times$
 - (-0.97, -0.01, 0.20) km/s in solar wind frame.
- Due to the ion energy spectrum, the heating of ions is weaker than ions in magnetosheath, so the structure is not the bow shock crossing.
- Compression ratio of this shock is about 4(the theoretical value), which shows that there is no other ion trapped process here.

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Part2|The FB shock structure and waves upstream it

No field-aligned current was observed at the center of the structure, which suggests that the structure is not a flux rope.



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Caption of the left figure

The corresponding mean magnetic field points in the maximumintermediate plane in each hodogram, separately. The data showed in hodogram are consistent with time interval in panel (X). The asterisk corresponds to the first measurement in this time interval.

- The frequency of these waves is about 2Hz, which is close to low hybrid wave frequency.
- The waves are right-hand polarized (in spacecraft frame) and circular polarized.

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Summary

- Using MMS data ,we report a foreshock bubble with a shock.
- The properties of the upstream shock is identified carefully.
- The waves upstream the FB shock is right-hand and circular polarization.

Future works

- We will check observations to see whether the waves upstream of FB shock are whistler precursor waves. These waves will be compared with whistler precursor waves upstream of bow shock and interplanetary shock.
- Ion and electron distributions will be check and the relationship between them and the waves activities will be analyzed.
- □ The complex structure of the shock will be analyzed further using multi-spacecraft methods.

Thank you!

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