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Quasi-Electrostatic Magnetosonic Waves in The Terrestrial Magnetosphere

Si Liu[1], Zhonglei Gao[1], Fuliang Xiao[1]

[1] School of Physics and Electronic Sciences, Changsha University of Science and Technology, Changsha, China

e-mail (speaker):liu.si@hotmail.com

Magnetosonic waves (MS) can significantly affect the terrestrial magnetosphere dynamics. MS waves are generally considered as electromagnetic harmonic fluctuations below the lower hybrid frequency. Here we present an observation of low harmonic magnetosonic waves with undetectable magnetic components that we call Quasi-Electrostatic Magnetosonic Waves (QEMS) by Van Allen Probe A. As shown in Figure 1, a series of banded quasi-electrostatic emissions appears between the first seven harmonics of the proton gyrofrequency f_{cp}, which are quite similar to electromagnetic MS waves on the frequency range, harmonic structures, accompanying with proton ring. We perform fully thermal simulations by fitting the measured proton distribution. Results (Figure 2a) demonstrate that the QEMS is excited as ion Bernstein mode by proton ring-like distribution. By using ratios between the wave electric and magnetic amplitudes E/B, the inferred magnetic spectral densities are below the instrument noise level (Figure 2b). The ratios E/B are ~7–80 times larger than the wave phase speeds (Figures 2c-2h), suggesting that the QEMS waves are essentially quasi- electrostatic. Furthermore, parametric studies are conducted to investigate how plasma environment affects the QEMS instability, as shown in Figure 3. As the background plasma number density increases or the hot (10 eV- 1keV) proton density decreases, the growth rates decrease, and significant growth rates occur in lower harmonic bands. This study provides further insights into the natures of MS waves in the magnetosphere.

References

[1] Gao, Z., Liu, S., Xiao, F., Zhou, Q., He, Q., Li, T., et al. (2021). Observation and fully thermal simulation of quasi-electrostatic magnetosonic waves. Geophysical Research Letters, 48, e2021GL095757.

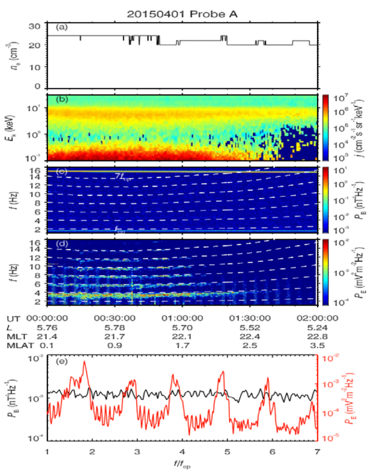

Figure 1. Quasi-electrostatic MS waves observed on 1 April 2015 by Van Allen Probe A. (a) Electron density ne, (b) proton perpendicular differential flux, dynamic (c) magnetic and (d) electric field power spectra, (e) magnetic (black line) and electric (red line) power spectra at 00:30 UT. Dashed lines in Figures 1c-1d represent 1–7 f_{cp}. (Figure 1 in Ref. [1])

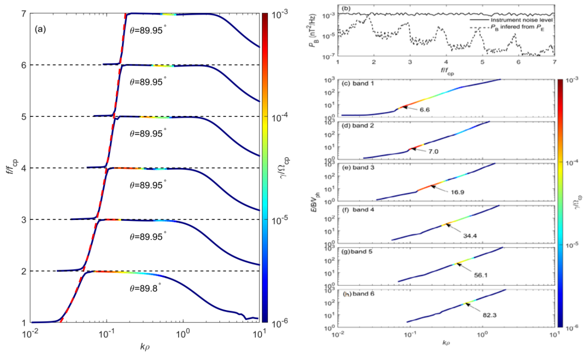

Figure 2. (a) Ion Bernstein mode instabilities for observation at 00:30 UT (Figure 3a in Ref. [1]). (b) The comparison between the observed magnetic field noise and the inferred magnetic filed power, (c)–(h) the ratio between E/B and the wave phase speed (Figure 4 in Ref. [1]).

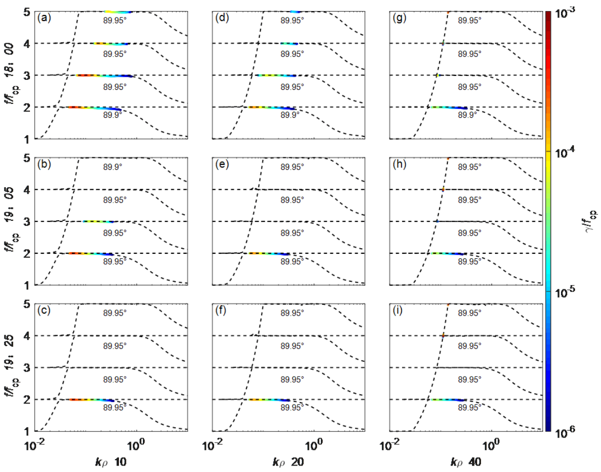

Figure 3. Parametric study for the growth rate of QEMS. Each row uses different cold plasma densities (Ne=10cc. 20cc. 40cc., respectively) but the same other parameters. Each column uses different hot (10 eV- 1keV) proton density but the same other parameters.