AGU PUBLICATIONS

Journal of Geophysical Research – Space Physics

Supporting Information for

Electromagnetic ion cyclotron wave fields in a realistic dipole field

R. E. Denton[1]

[1]Department of Physics and Astronomy, Dartmouth College, Hanover, New Hampshire, USA

Contents

Introduction

Here we describe Table S1 that lists properties of wave solutions at different latitudes.

We also describe several supporting data sets that are all stored in external files. These are:

DentonEMIC17_ds01.csv
DentonEMIC17_ds02.csv
DentonEMIC17_ds03.csv

Each of these files uses ASCII characters and has explanatory material at the top of the file. All quantities are in normalized units (explained at the top of each file), except for the time t, which is in s. In order to convert to the time normalized to the proton gyrofrequency at the normalization point (magnetic equator on the central field line), divide the time in s by 10.

All of these files are available in a Zenodo data repository. At that location, there are also programs that read the data and generate a plot.

Table S1 Wave solutions at different latitudes

Below are quantities that depend on the q or MLAT value. The value of B/B_{eq} increases with latitude. Consequently, the hot proton density, $N_{hot,}$ and temperature ratio, $T_{\perp hot}/T_{//hot}$, are also modified [Hu and Denton, 2009]. The maximum growth rate, γ_{max}, and wave frequency for maximum growth rate, ω_{max}, normalized to the local proton gyrofrequency, $\Omega_{cp,local}$, are listed for the O, He, and H modes.

For the dominant He mode only, we consider the effect of propagation of these waves to higher latitude. For these waves, generated at the magnetic equator with $\omega = \omega_{maxHe}/\Omega_{cp} = 0.184$, where Ω_{cp} is the equatorial proton gyrofrequency, we find the wave frequency normalized to the local proton gyrofrequency, $\Omega_{cp,local}$, by multiplying 0.184 by B_{eq}/B.

	q = 0.1, MLAT = 2.6°	q = 0.3, MLAT = 7.9°	q = 0.5, MLAT = 13.7°	q = 0.7, MLAT = 20.9°
B/B_{eq}	1	1.1	1.3	1.8
N_{hot}	1	0.92	0.81	0.69
$T_{\perp hot}/T_{//hot}$	2	1.84	1.62	1.38
$\gamma_{maxO} / \Omega_{cp,local}$	$1.5x10^{-3}$	$7.3x10^{-4}$	0	0
$\omega_{maxO} / \Omega_{cp,local}$	0.059	0.059		
$\gamma_{maxHe} / \Omega_{cp,local}$	$1.7x10^{-2}$	$1.1x10^{-2}$	$4.3x10^{-3}$	$5.1x10^{-4}$
$\omega_{maxHe} / \Omega_{cp,local}$	0.184	0.186	0.192	0.204
$0.184\ (B_{eq}/B)$	0.184	0.171	0.145	0.104
$\gamma_{maxH} / \Omega_{cp,local}$	$9.2x10^{-3}$	$6.0x10^{-3}$	$2.1x10^{-3}$	0
$\omega_{maxH} / \Omega_{cp,local}$	0.316	0.316	0.313	

Description of DentonEMIC17_ds01.csv

DentonEMIC17_ds01.csv has the position and time dependent magnetic and electric field data from t = 50 s to 130 s (times used in the paper). The fields are given at the grid points of the dipole magnetic field using the parallel q coordinate that varies from 0 at the magnetic equator to 1 at the upper boundary and the perpendicular r coordinate that is equal to the L shell normalized to the central value, L0, so that r = L/L0. Because q has a complicated definition (see paper), the magnetic latitude MLAT is also given in degrees so that the exact spatial location of each grid point can be more easily determined. The q component of the fields is along the dipole magnetic field, the r component is perpendicular to the dipole magnetic field radially outward in the meridional plane of the simulation, and the s component is in the azimuthal direction in a right-handed sense (q-r-s).

Description of DentonEMIC17_ds02.csv

DentonEMIC17_ds02.csv is similar to DentonEMIC17_ds01.csv in that it lists the magnetic and electric field data versus position and time. There are two differences. First of all, the fields in this file are given in field aligned coordinates. To define these coordinates, the q and r components of the magnetic field averaged from 10 s earlier than the time listed to 10 s later than the time listed are given. Then the pl (parallel) component of the magnetic or electric field is along that average field, the pr (perpendicular in the meridional plane) component of the magnetic or electric field is perpendicular within the meridional plane directed outward, and the s component is the azimuthal component in a right-handed sense (pl-pr-s). These data are only given for the four times used in the plots in the paper, 60 s, 80 s, 100 s, and 120 s. These magnetic field data are plotted in Figure 1.

Description of DentonEMIC17_ds03.csv

DentonEMIC17_ds03.csv gives the spectral distribution of waves around the four times analyzed in the paper, 60 s, 80 s, 100 s, and 120 s. The parallel and transverse fields are Fourier transformed in time and in both directions in space, using the pl-pr-s field aligned coordinate system defined above. Since these spectra are calculated within the four boxes centered at points along the central field line (r = L/L0 = 1; see Figure 1), only the magnetic latitude MLAT is given to specify the position. So the spectra are given for four positions at four times. Here the signs of the wave vectors are not reversed for negative frequencies. So if you want to make positive wave vector correspond to waves propagating in the positive direction, you need to reverse both components of the wave vector for negative frequencies. But if you want to transform back to real space, do not reverse these components of the wave vector. Each Fourier mode has a real and imaginary part. To find the wave power in each mode, multiply the mode times its complex conjugate. The real parallel (pl) component of the magnetic or electric field is transformed, and the transverse components (pr and s) are combined into a complex quantity, Fpr + i*Fs for field F (B or E), as described by Kodera et al. [1977]. The modes have the following time and space dependence: exp(i*(omega*t – kpl*spl – kpr*spr)) (with no additional multiplicative normalization factor), where omega is the real frequency, kpl and kpr are respectively the pl and pr components of the wave vector, and spl and spr are respectively the pl and pr components of the displacement from the central grid point of the box. After transforming the transverse field back to time and space, the real part of the resulting quantity is Fpr and the imaginary part is Fs. The parallel component should be approximately real after the inverse transformation. (It won't be exactly real because of the data windowing used in the Fourier transformation.)