Space Physics

Practical 2B

Data Analysis

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1 Introduction

2 Time Series Data

2.1 Question 1

Where in the magnetosphere are the observations made? Motivate you answer!
The measurment taken on 2002-03-02 at 03:29-03:30 is taken at the time when the satellite was crossing the border of magnetopause.

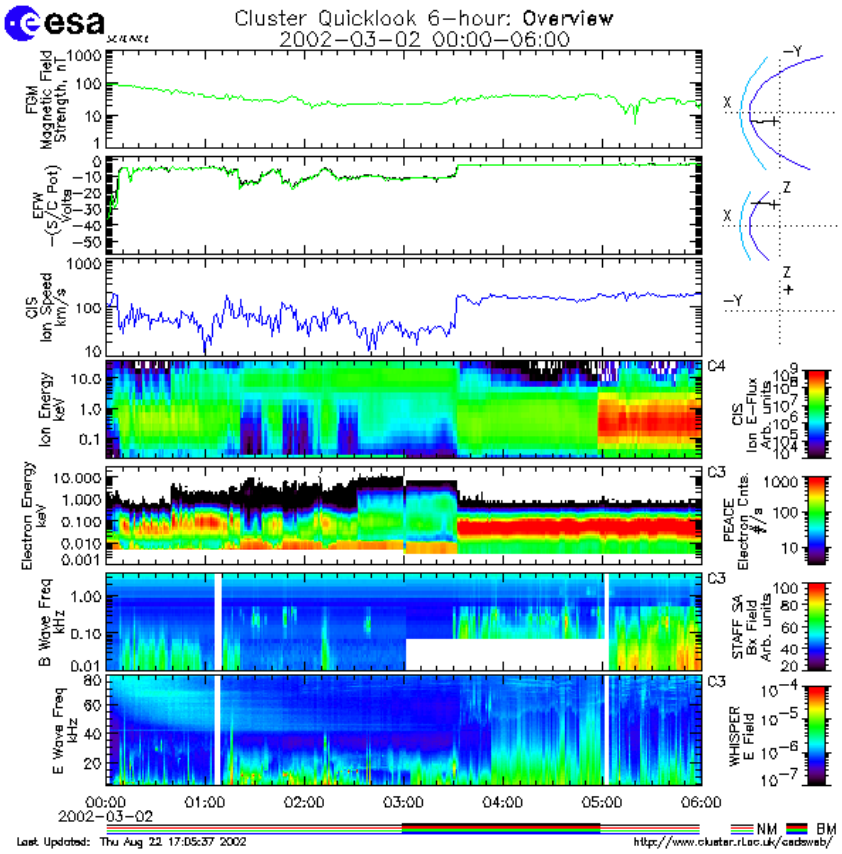


Figure 1: Cluster Quicklook 6-hours overview.

2.2 Question 2

Plot the time series (all components) from the three instruments. Can you identify any waves? What type of waves are we looking at: Electrostatic or electromagnetic? Is there a need to correct the data somehow? If so, why and how do you do that?
Electromagnetic between 20 and 30 s. Electrostatic between 55 and 60 s. x component is facing towards the sun. It should fluctuate around zero, like the y-component does it. It happens because of the photon emission, which is captured by the probes. Thus, data correction is needed.

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.10.25

How do you do his correction?
There is also another feature that should be corrected. Which?

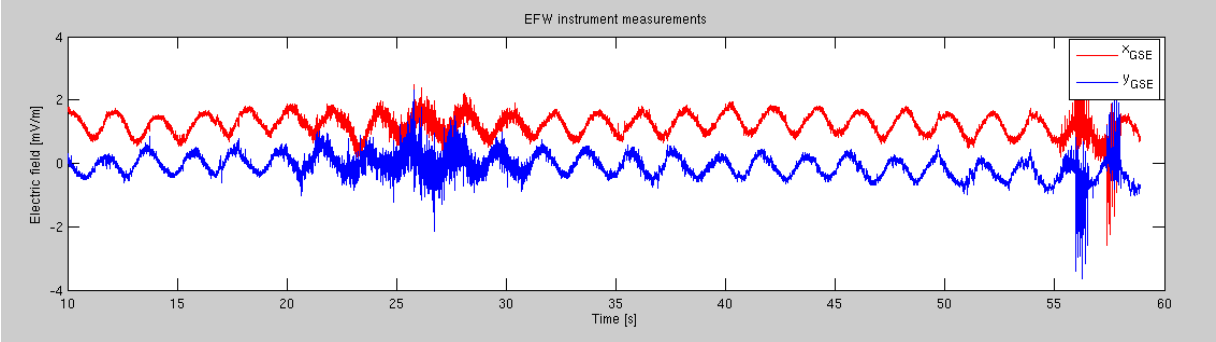


Figure 2: EFW Measurement Data

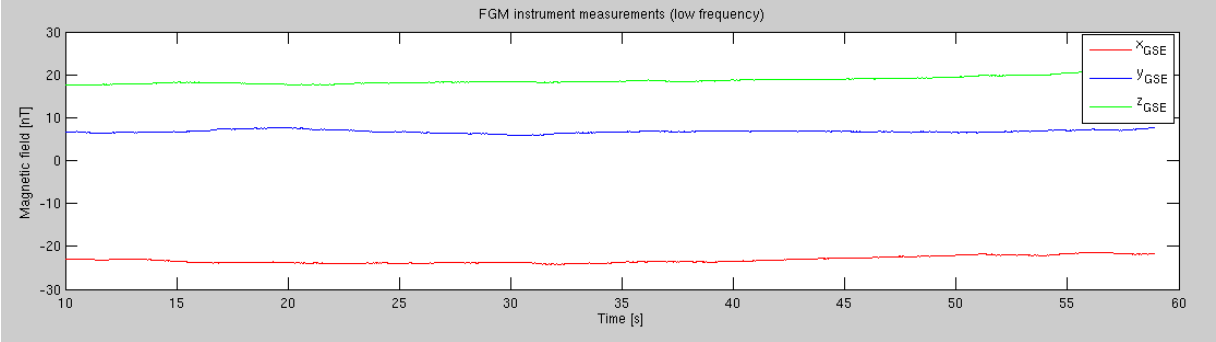


Figure 3: FGM Measurement Data

2.3 Question 3

Estimate the frequency of the waves by looking at the times series only. Describe how you do. What is you result?

Roughly estimated wave period is about 0.01 s (zoomed in and estimated between 2 peaks). Frequency = 1/0.01 = 100 Hz.

2.4 Question 4

Compute the fundamental frequencies (electron and proton gyrofrequencies and the electron plasma frequency) in the plasma. The background magnetic field you have in the data. The density can be found from the overview data. However, the ion density is usually underestimated. Therefore, it is a good idea to compare with the high frequency emissions obtained by the WHISPER instrument. In the WHISPER data you can identify the electron plasma frequency directly, as a thin horizontal line visible most of the time. What density does the WHISPER signal correspond to? Compare the wave frequency with the fundamental frequencies. What are you conclusions?

From overview data, ion density is $1.5cm^3$. The minimum and maximum Electron gyrofrequency are 0.82 kHz and 0.88 kHz respectively while the minimum and maximum Proton gyrofrequency is $4.5X10^4$ Hz and $4.8X10^{-4}$ Hz respectively. The electron Plasma frequency is 10.9 kHz considering a density of $1.5cm^3$. The estimated plasma frequency from WHISPER is 16 kHz.

Sida: 5

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.12.58

What are your conclusions?

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.11.42

Wrong unit or wrong values!

Antal: 3 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.12.22

What density does this correspond to?

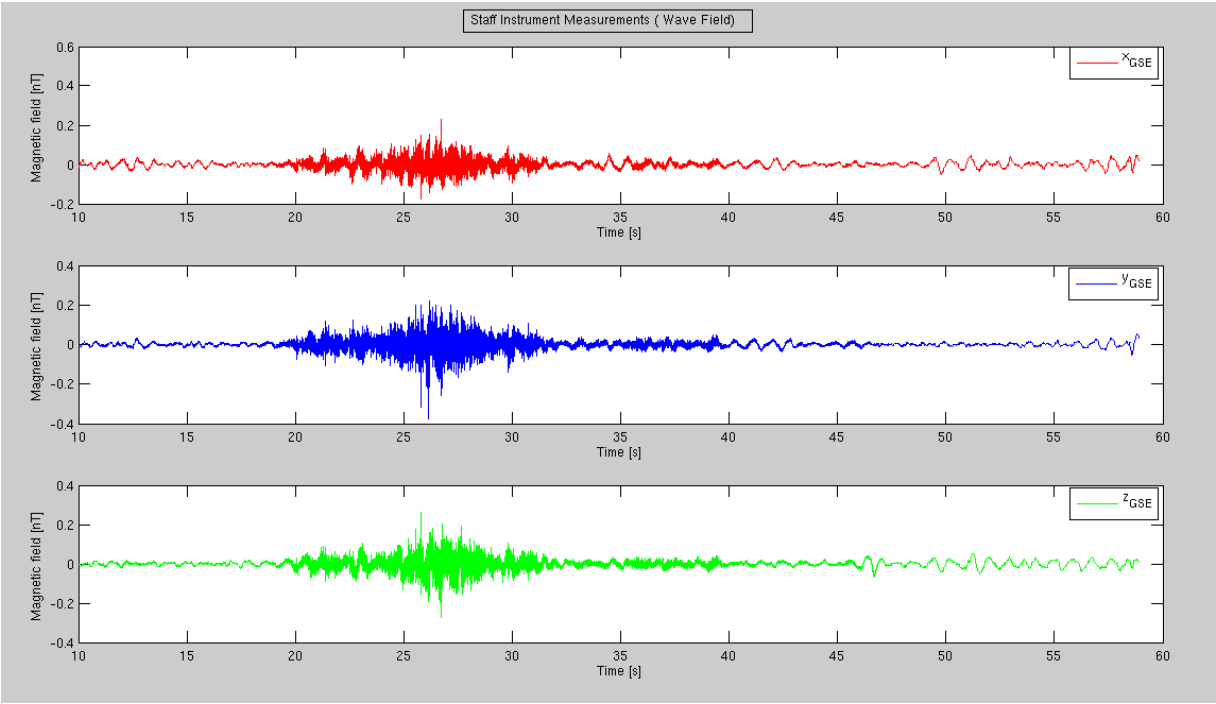


Figure 4: Staff Instrument Measurement Data

2.5 Question 5

Compute the PSD of the electric and magnetic wave fields for the entire time period. If you want you can use the Matlab-function PSDvsFREQ(). Compare with your results obtained in 2 and 3. Also, investigate the how the error changes when you sum over fewer records. If you want you can use the errorbar() function to visualize this. Which are your conclusions?

1 The Figures 5 and 7 show the PSD of electric and magnetic field respectively. The Figures 6 and 8 show the PSD with error bars. 2 The peaks are around 90-100 Hz. Which corresponds to our rough estimation in question 3. The Figures 12 and 10 show the PSD of electric and magnetic fields when fewer records have been used. It can bee seen the the error is less when less records are used.

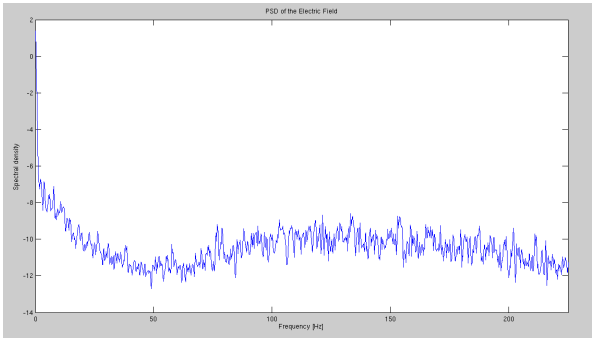


Figure 5: PSD of Electric Field.

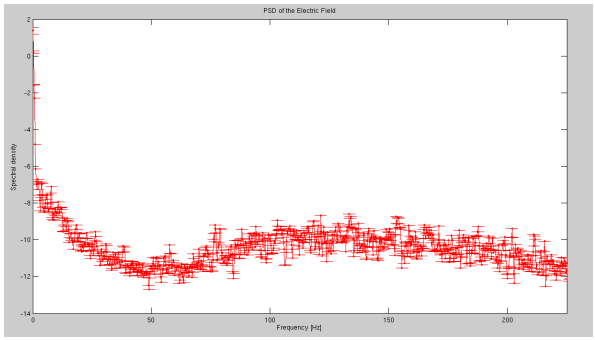


Figure 6: PSD of Electric Field with Error Bar

Sida: 6

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.17.24

It is difficult to read the axes text in your figures.
Also, unit for y-axis are missing!
If you adjust your y-axis range you se the relevant signal better.

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.17.47

In which frequency range do you have waves?

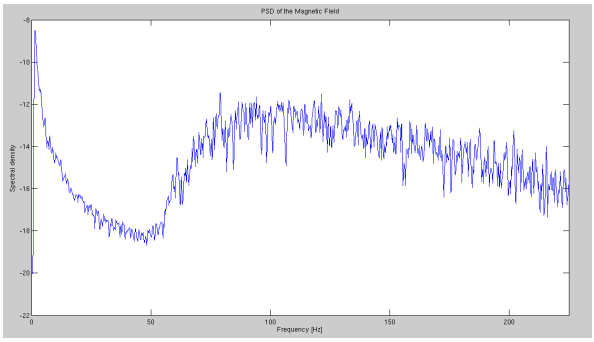


Figure 7: PSD of Magnetic Field.

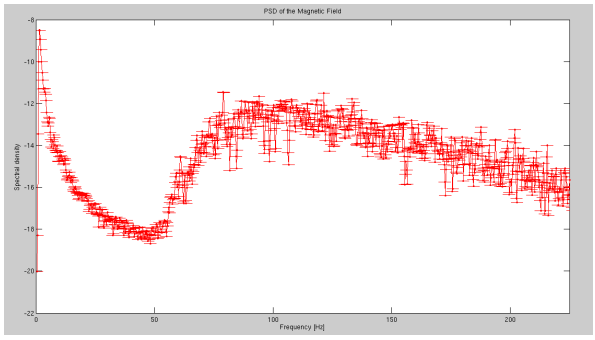


Figure 8: PSD with Error Bar

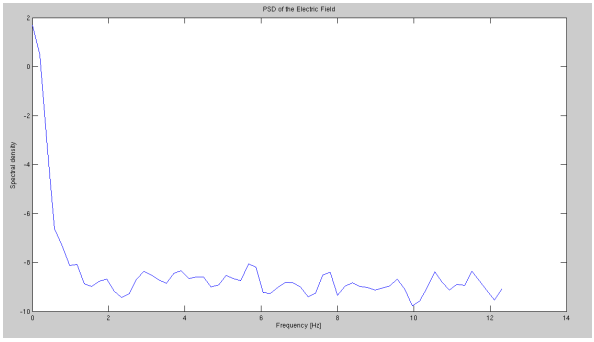


Figure 9: PSD of Electric Field with less records

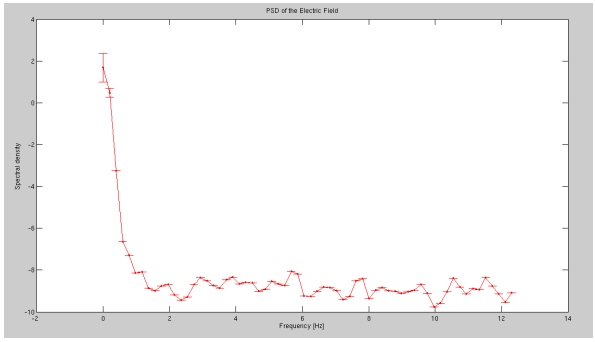


Figure 10: PSD with Error Bar and less records

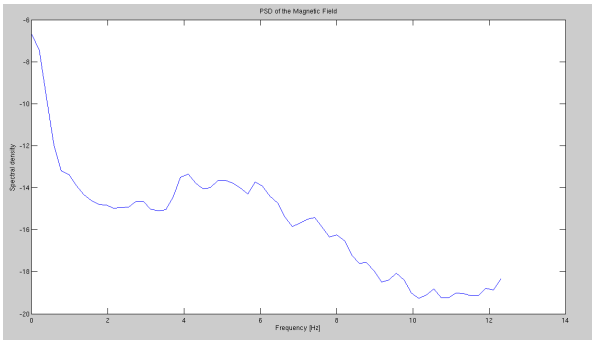


Figure 11: PSD of Magnetic Field with less records.

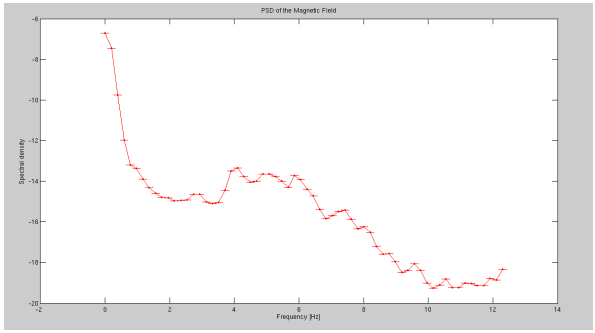


Figure 12: PSD with Error Bar with less records

2.6 Question 6

Look at (=make PSDs for) two different frequency ranges: 0-225 Hz and 0-2 Hz. You should aim at good statistics so the frequency resolution should be different in the two plots. The frequency resolution is given by $f = 1/Nt$*, where* t *is the time between two samples and* N *is the record length used in the Fourier transform. For each of the plots: provide all the information about the PSD you present: The length of the record, the shift between records and the total number of records used.*

The Figures 13 and 14 show the PSD of electric and magnetic field for 0 to 2 Hz frequency. The errors are more easily visible in this PSD.

Sida: 7

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.23.23

These plots looks strange. What parameters did you use?
Also, the frequency axis is not correct!

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.24.10

These plots looks strange. What parameters did you use?
The frequency axis is not correct. Please give unit on y-axis.

Antal: 3 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.24.33

These figures also look strange. Which parameters did you use? What frequency resolution do you have?
You should be able to see the low frequnecy signal in the electric field!
Units on y-axis!

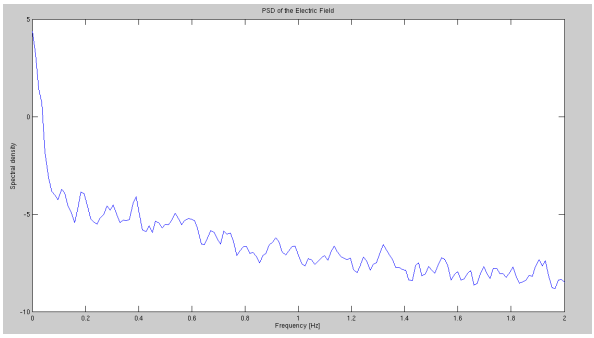


Figure 13: PSD of Electric Field for frequncy 0 to 2 Hz

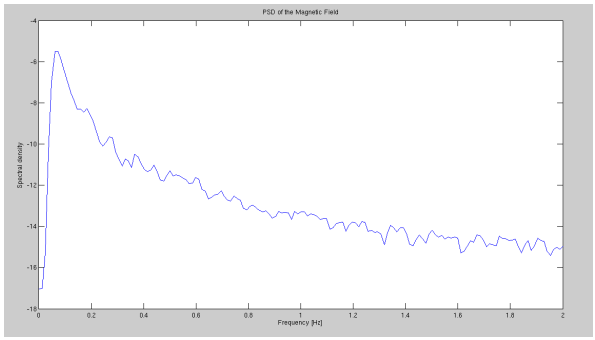


Figure 14: PSD of Magnetic Field for frequency 0 to 2 Hz

2.7 Question 7

Plot spectrograms (=PSD versus time and frequency) of both the electric and magnetic fields. You can do this by using the Matlab function means() and ignoring the wave vector output. Try different resolutions in time and frequency.What are you conclusions?

The Figures 15 and 16 show the spectrogram of electric and magnetic field respectively. There is an increase in the power at all frequencies at about time 300 seconds. This might be when the spacecraft is close to the magnetopause. The Figures 17 and 18 show the spectrogram with lower resolution in time and frequency, which makes it difficult to clear identify the region of high spectral power density.

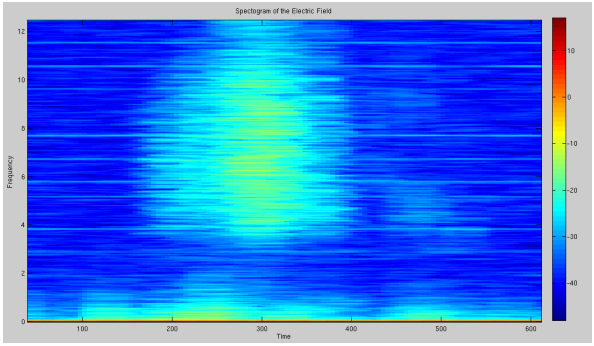


Figure 15: Spectrogram of Electric Field with high time and frequency resolution

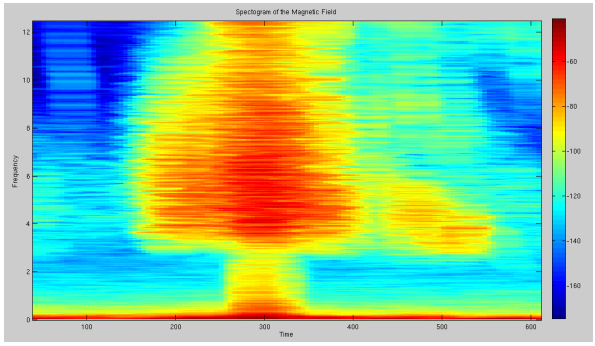


Figure 16: Spectrogram of Magnetic Field with high time and frequency resolution

2.8 Question 8

Now we can produce a so-called hodogram , which shows how the wave field vector moves in the plane perpendicular to B0. If the field vector moves in the same direction as a positive ion would gyrate then the wave is left-hand polarized. If the vector rotates in the opposite direction the wave is righthand polarized. Plot the magnetic field vector in this plane and determine the polarization of the waves. Sometimes it is easier to see the rotation if you normalize the length of the vectors to 1. Do the same with the electric field wave vector.

The Figures 19 and 20 show the hodogram for the electric and magnetic field respectively. The electric field shows no particular polarization but hodogrom of magnetic field seems to moving in counter-clock wise

Sida: 8

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.25.47

The entire time seris you analyse is 60 seconds, so this cannot be correct.
The frequnecy axis is also strange. Previously you estimated the frequnecy to about 100 Hz?

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.26.27

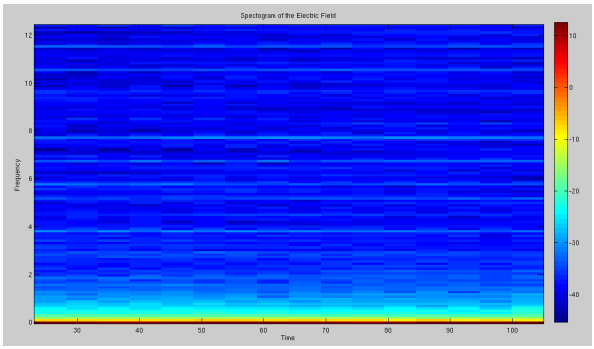
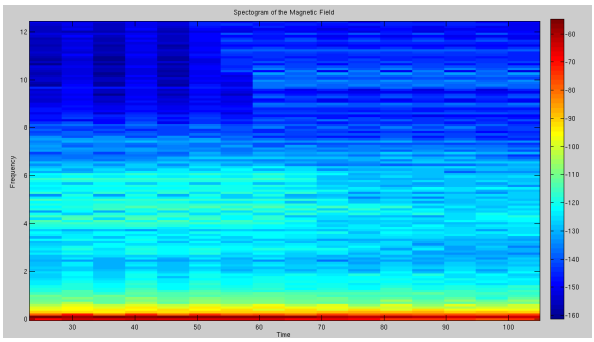
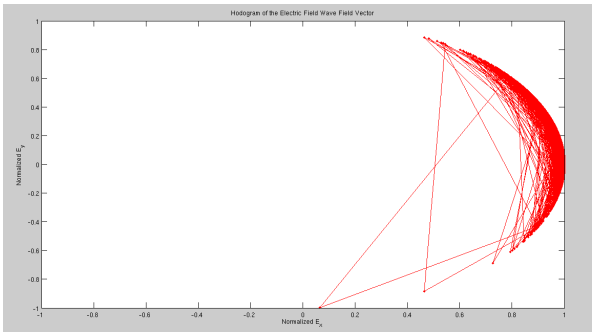


Figure 17: Spectrogram of Electric Field with low time and frequency resolution



1igure 18: Spectrogram of Magnetic Field with low time and frequency resolution

directiona and hence the magnetic field is right hand polarized.



2igure 19: Hodogram of Electric Field.

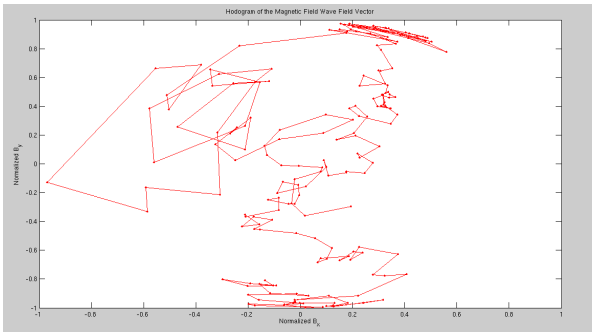


Figure 20: Hodogram of Magnetic Field

Sida: 9

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.27.59

Here you must compute the spectrum for the entire interval! You don't see any waves in these plots?!

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.29.20

You have to use fewer points (10-20 or so).
Also, are you really plotting points 'inside' the wave? Which points did you plot?

3 Particle Measurements

For this part of the practical we have been provided the particle data from the SWIM instrument onboard the Chandrayaan-1 spacecraft. Chandrayaan-1 orbits the moon at an altitude of 100 km. The position of the spacecraft at different times is shown in the Figures 21 and 22, which also show the position of the moon with respect to Earth.[2]

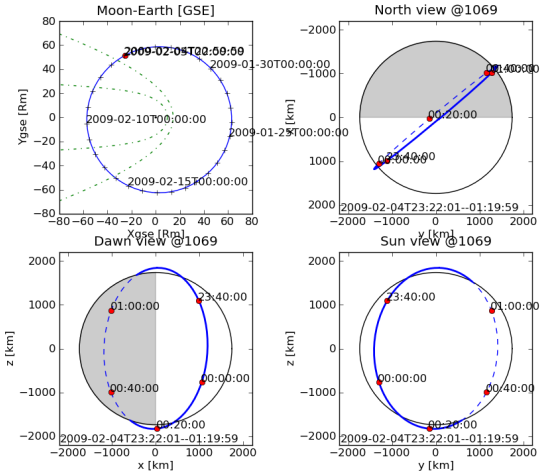


Figure 21: Position of the instrument in Orbit 1069

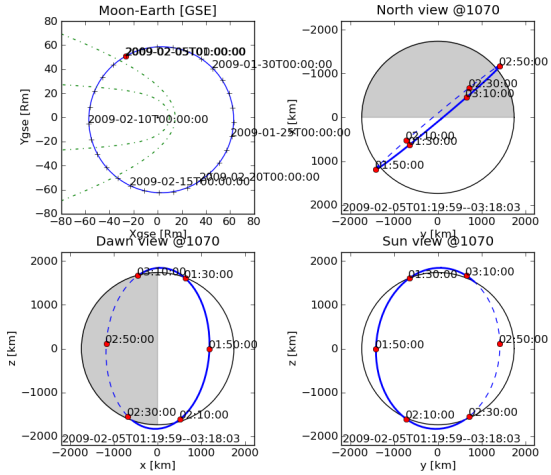


Figure 22: Position of the instrument in Orbit 1070

3.1 Question 1

Plot spectrograms, that is, the number of counts versus time and energy, for the two orbits. The different energy levels you find in a comment line in the data files. Once every orbit SWIM looks at the solar wind. Identify when this happens in the two orbits.

The spectrograms for the orbits 1069 and 1070 is shown in Figure 23 and 24 respectively. When SWIM looks at the solar wind the number of solar wind particles that hit the instrument increases significantly which is observable as the red portion in Figures 23 and 24. For orbit 1069, it occurs approximately between $100th$ and $350th$ observation time bin which corresponds to UTC 05:29 to UTC 06:02 hours. For orbit 1070, it occurs approximately between $25th$ and $250th$ observation time bin which corresponds to UTC 07:22 to UTC 08:12 hours.

3.2 Question 2

Protons are the main ions in the solar wind, but can you identify any other components? Motivate you answer!

Helium ions He^{2+}. The instruments measure E/q ratio. The helium ions and protons have the same E/q ratio.

3.3 Question 3

Make energy spectra, this is, plot observed counts versus energy for a selected time interval around the solar wind observation.

Sida: 10

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.32.16

The energies of the peaks are not correct:
If you use image() to plot. Try pcolor instead.
Also, we normally plot time on the x-axis and energy on y.
And to log the counts are probably a good idea.

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.32.58

No!

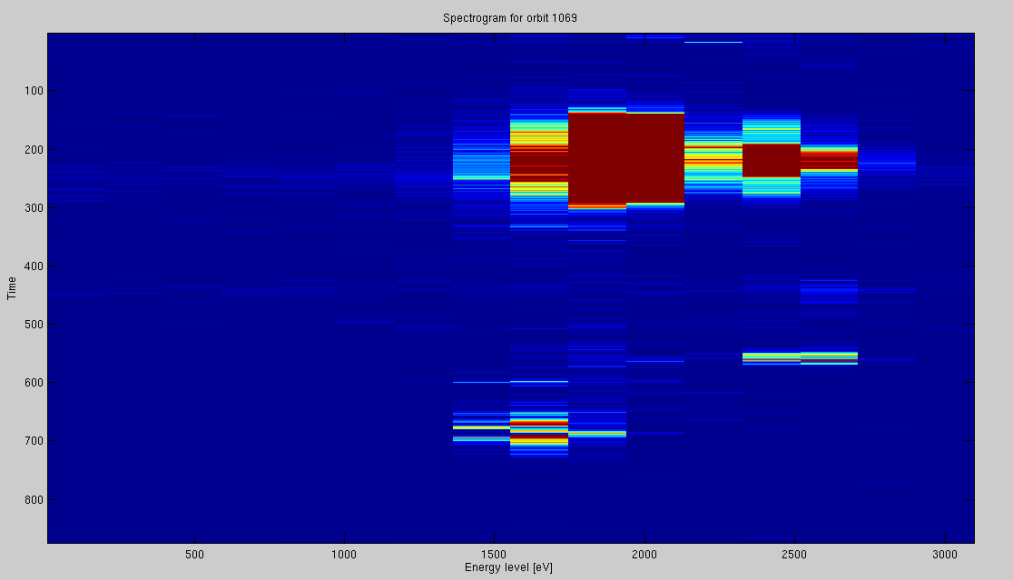


Figure 23: Spectrogram of the 1069 Orbit

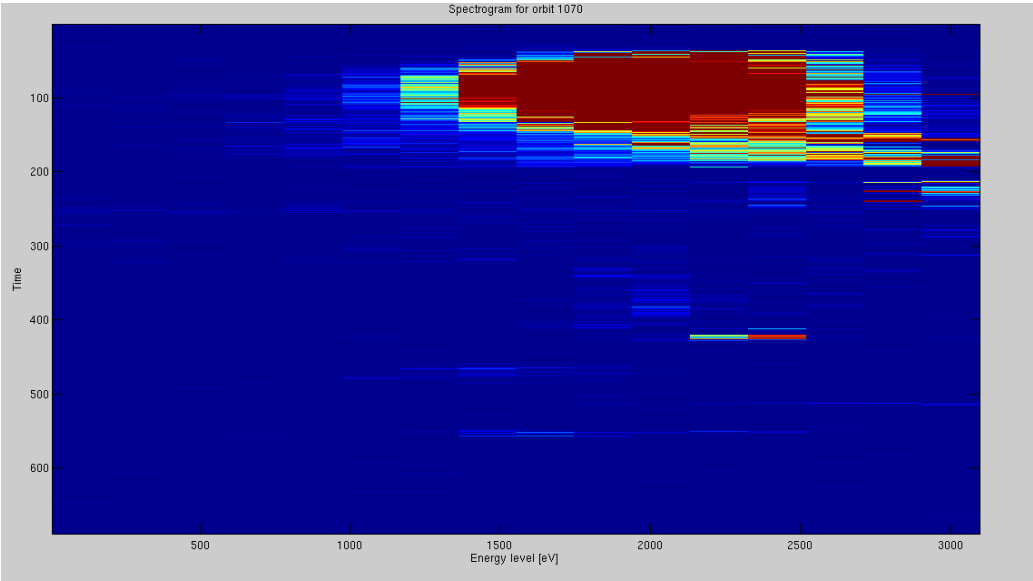


Figure 24: Spectrogram of the 1070 Orbit

The energy spectra for the time when the SWIM instrument looks at the solar wind for the orbit 1069 and orbit 1070 is shown in Figure 25 and 26 respectively

3.4 Question 4

Determine the solar wind proton velocity and temperature by first transforming the data from energy to velocity space and then fitting a Maxwellian distribution. What temperatures and velocities do you get? Are there differences between the orbits? If so, why?

Sidan innehåller inga kommentarer

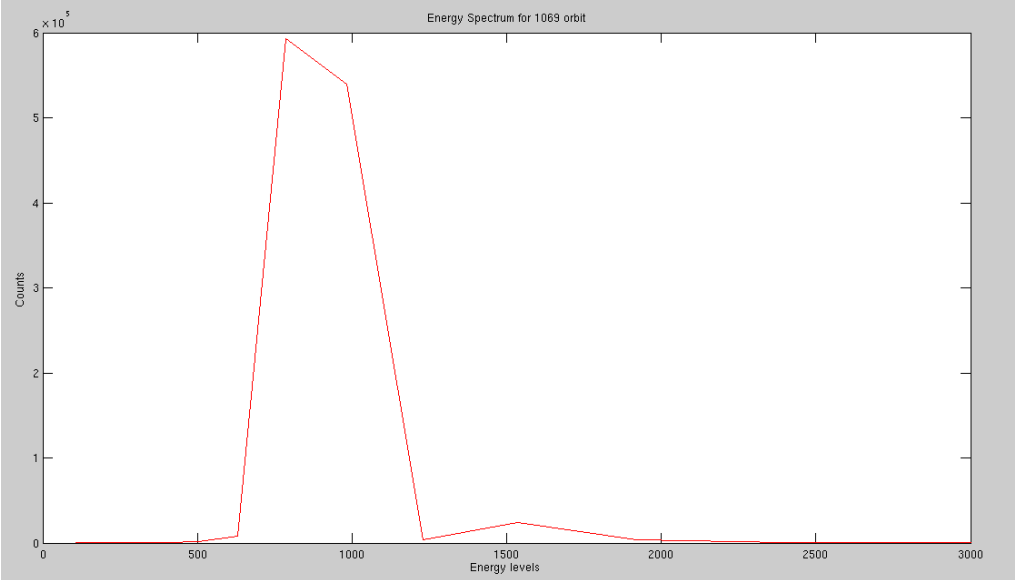


Figure 25: Energy Spectra of the 1069 Orbit

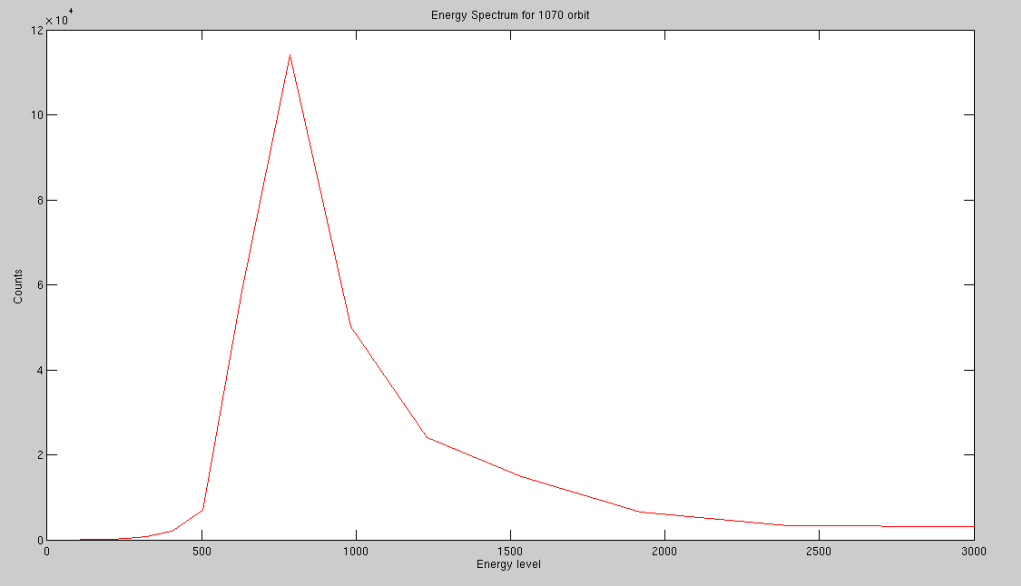


Figure 26: Energy Spectra of the 1070 Orbit

For the orbit 1070 the proton velocity is 389.4 Km/s and temperature is 9,184,931 K and for the orbit 1069 the proton velocityis 410.1 Km/s and the temperature is 10,187,404 K

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.35.47

The temperatures seem very high to me. How did you arrive at this result?

3.5 Question 5

How do you determine the velocity of other components in the solar wind? What results do you get?

The velocity of other components is also determined in the same way as protons. They would give out the same values as protons because the instrument measures E/q values which is the same for proton and He^{1+}.

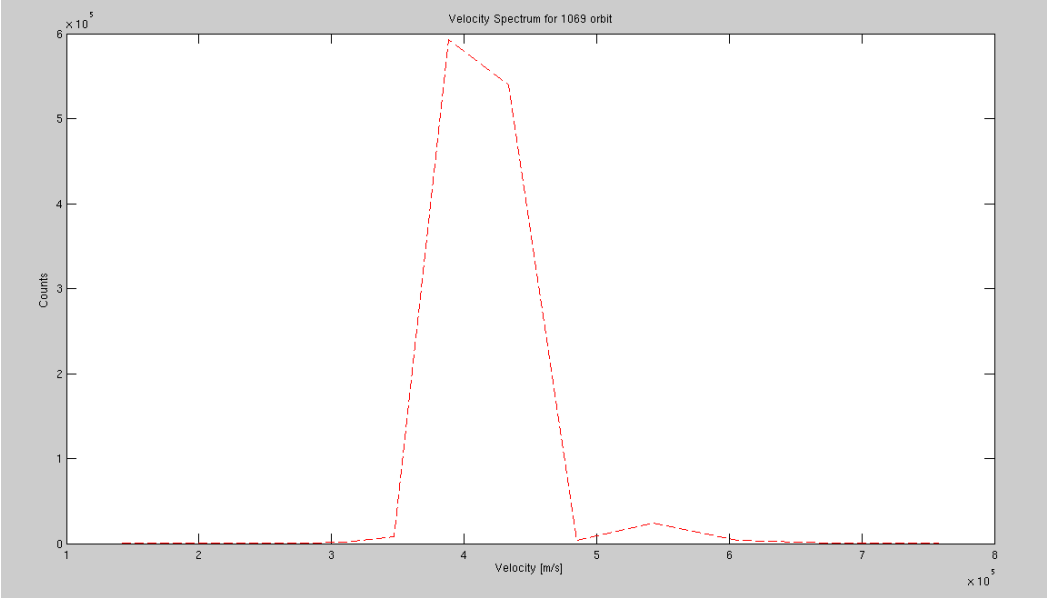


Figure 27: Velocity Spectra of the 1069 Orbit

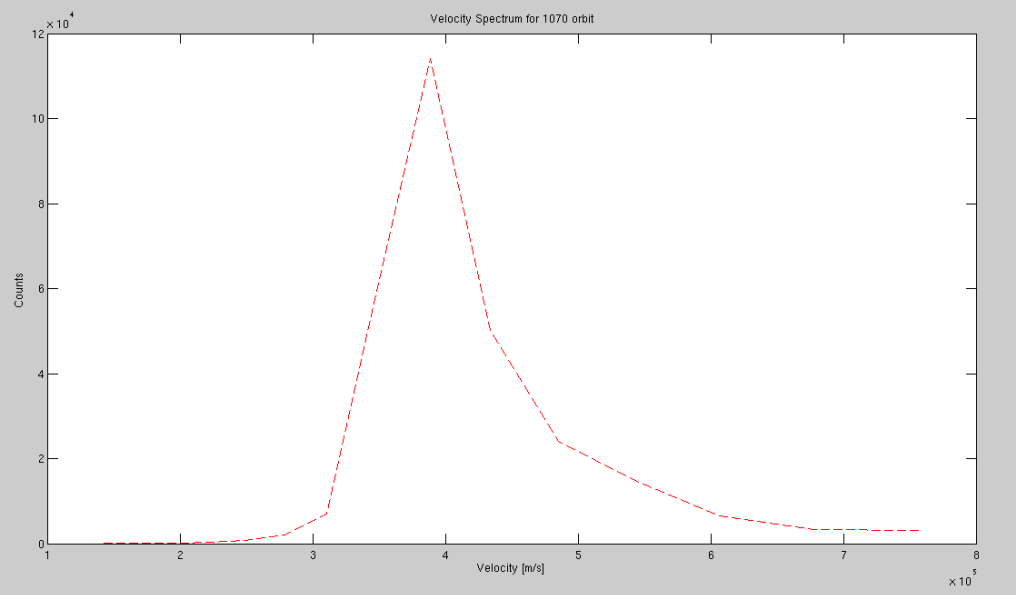


Figure 28: Velocity Spectra of the 1070 Orbit

Sida: 13

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.36.50
This is not true!

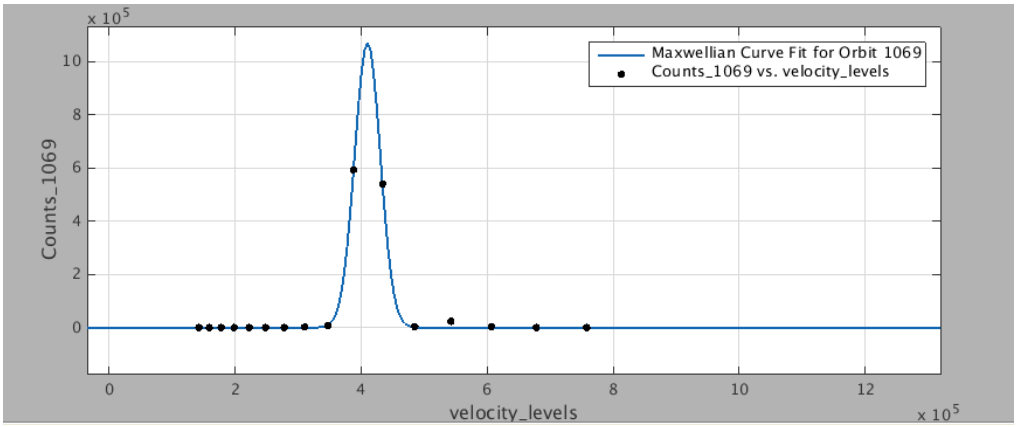


Figure 29: Maxwellian Curve fit for data from Orbit 1069

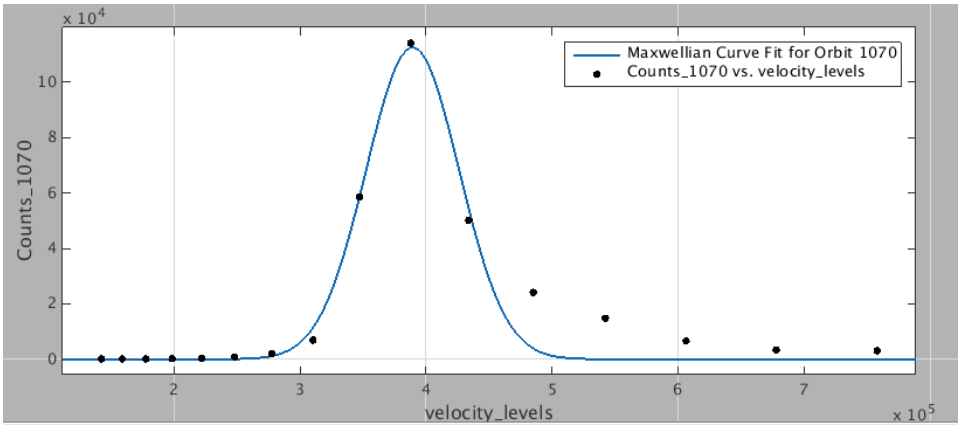


Figure 30: Maxwellian Curve fit for data from Orbit 1070

3.6 Question 6

Compare your results with the observations made by one of the spacecrafts ACE or WIND: `http://www.srl.caltech.edu/ACE/ASC/level2/lvl2DATA_SWEPAM.html` *or* `ftp://space.mit.edu/pub/plasma/wind/kp_files/`*. Note that the ACE/WIND measurements are made far upstream of the spacecraft so you have to compensate for this when you compare.*

Data was retrieved for the same date and hour as the swim instrument and the proton velocity according to this data is 377.2 Km/s and the temperature is 39,327 K. The minor difference is due to the reason that ACE makes measurements far upstream. [1]

Sida: 14

Antal: 1 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.38.34

You have two different times to look at. And you also have to compensate for that ACE makes observations at a different place! How do you do that?

Antal: 2 Författare: gabriella Ämne: Kommentar till text Datum: 2012-06-01 12.37.29

Minor difference??

References

[1] ACE SWEPAM Level 2 Data. *Measurements from the satellite ACE.* `http://www.srl.caltech.edu/ACE/ASC/level2/lvl2DATA_SWEPAM.html`.

[2] Stenberg G. (2012). *Practical 2B. Data Analysis.* Luleå University of Technology, Kiruna, Sweden.

Sidan innehåller inga kommentarer