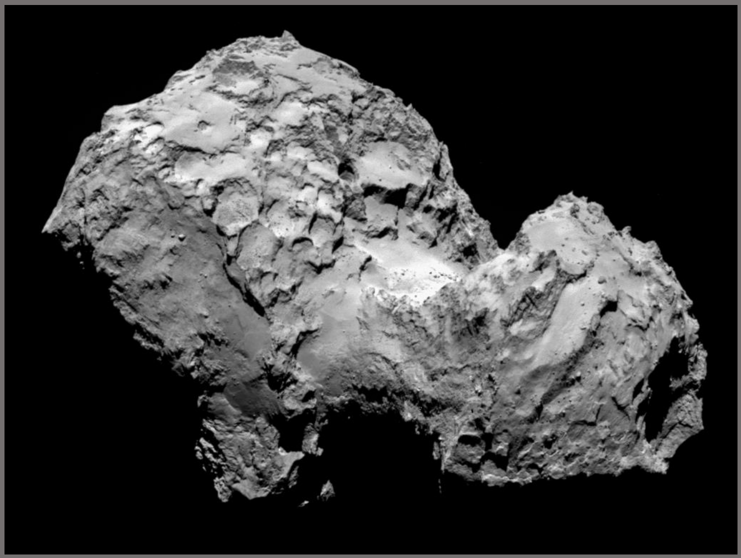
Luleå University of Technology

Space Physics

Light Mass Loading at 67P



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0 – Load the data, look at the different variables of the structure, their size, their meaning. Compare this sizes/dimensions with the instrument description above.

What type of physical values are stored in each variable?

Explain the shape of the variable 'spectra'.

Different variables of the structure are:

Magnetic field, B: It is a matrix with dimensions 3×56 i.e. we have 56 values of magnetic field in three dimensional space. It is formed because of motion of electric charge carriers or plasmas in space. These electric charge carriers can be protons or alpha particles coming from the solar wind or ions formed due to collisions of solar particles with comet's atmosphere.

Energy per charge of the particle, E: It is the kinetic energy per charge of a charged particle. Its dimensions are 1×96 i.e. we have 96 values for the energy of the charged particle. The instrument measured energy of the incoming particles in 96 steps i.e. from 30 eV to 40 keV with a resolution of $\frac{\Delta E}{E} = 0.07$.

Azimuth, azim: It is a matrix of dimension 1×16 i.e. we have 16 values of azimuth angle. It is the angle formed between the projected vector (vector from Rosetta to pint of interest projected perpendicularly on a reference plane) and the reference vector on the reference plane. It can vary between 0° to 360°. The resolution of the instrument for measuring azimuth is 22.5°.

Elevation, elev: It is a matrix with dimensions 96×16 i.e. elevation angles are measured for each possible energy value of the particle detected by the instrument ICA. It is the angle between the particle and Rosetta's local horizon and can vary from 0° to 90°. The resolution of the instrument for measuring elevation angle is 5°.

Spectral values, spectra: It is a five dimensional matrix (56×16×16×96×32) with its five dimensions being time, elevation, azimuth, energy of the particle and mass of the particle. Using this matrix, it is possible to answer the question "what flux (spectral value) of what species (mass)at which particular position (elevation and azimuth)was flowing with what velocity (energy and mass) at what time".

Time, time: It is a matrix of dimension 1×56 i.e. we have 56 entries of time. It is a component quantity used to sequence events. Time given in the matrix is Universal Time.

1 – Plot the spectrogram of the data set (energy vs time) as a color map (see pcolor). Use the energy vector (or energy table) for the y axis. Try to plot with and without the time vector for the x axis. Why does it look different?

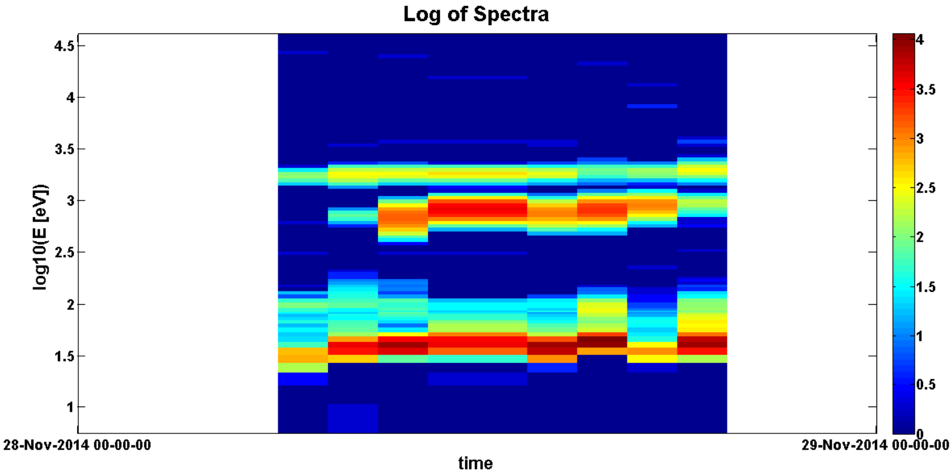

Figure 1: Spectrogram with time vector for the X-axis

It can be seen from here that most of the particles have energies of the order of 30 eV and 1 keV. Since our instrument can only detect particles with energies greater than or equal to 30 eV, these observations are in coherence with what we expect. Also, it can be seen that most of the particles do not have a very high energy.

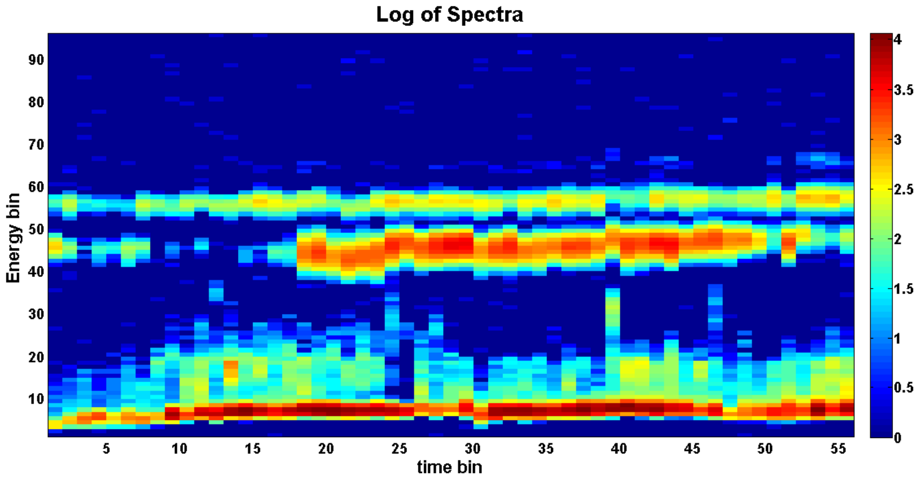

Figure 2: Spectrogram without time vector for the X-axis

From this spectrograph, we can draw the same conclusion i.e. most of the particles do not have enough energy most of the time. But there is a fraction of particles with sufficiently high energies (around 1 keV as depicted in the spectrogram above).

Both the spectrograms appear different because of the scale of the axis we have used. In the first spectrogram, we used logarithm of the energy values in eV whereas in the second one, we just used the bin number of the energy level. Therefore, it is a little difficult to determine the energy level of most of the particles from the second spectrogram, whereas it is easy to predict the energy levels of majority of the particles detected by ICA by just looking at the first spectrogram.

2 – Plot the energy-mass matrix (integrated over time): mass as x-axis, energy as y-axis, color map with counts as color. This time, withoutusing the energy table.

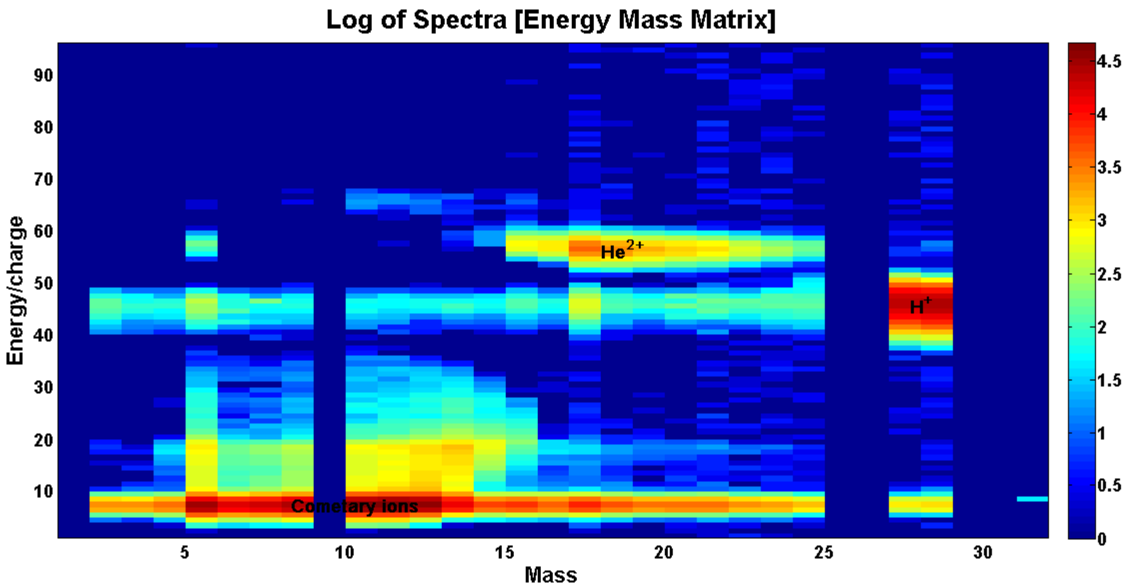

Figure 3: Energy-mass matrix (integrated over time)

3 – On the previous plot, identify the species, and explain their position in terms of both energy and mass.Report their position in terms of mass bins [m1, m2] and energy bins [e1, e2]. Try to find at what energy per charge solar wind components/ species should be expected. What general region of the energy-mass matrix should each species end up?

The above figure shows Energy mass Matrix which is integrated over one day. The different species can be identified on this Energy-mass matrix. Most of the protons are detected in Mass bin 27-28 and energy bin between 40-50 (approximately 1 keV) on the left side of the spectrogram. Since solar protons have very light mass and high energy, so they should lie in the region shown in the spectrogram in Fig. 3. We expect cometary ions (like H_2O^+) to be heavy and have low kinetic energies, hence they are found lower left region of Fig. 3. Since alpha particles are heavier than solar protons and lighter than cometary ions, we expect to see them in the region indicated on Fig. 3. Also, since most of the alpha particles come from solar wind, they will have higher velocities as compared to cometary ions. Solar wind is mainly composed of protons and alpha particles. So, both alpha particles and protons will have same velocity as solar wind. But since alpha particles have more charge and mass than solar protons, their kinetic energy per charge will be little bit higher than solar protons. Also, a diffused area above the solar proton and alpha particles can be observed in Fig. 3. This diffused area is a result of motion of ionized particles (solar particles) in electromagnetic field.

4 – Plot azimuth versus elevation (Field Of View FOV), integrated over time first. We can discuss here before the following steps. What is the dark area covering ~1/4 of the FOV?

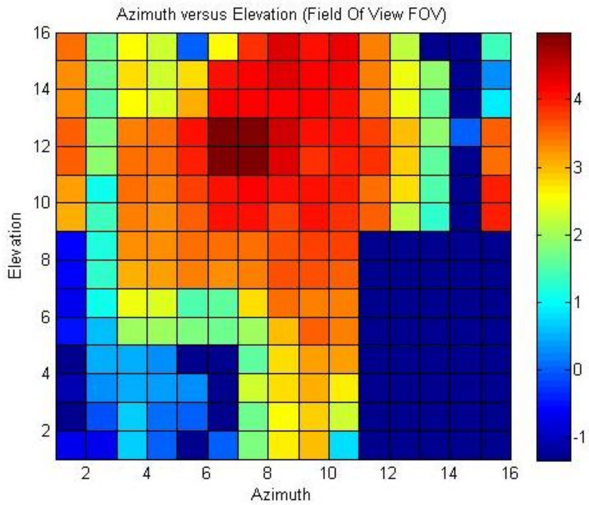

Figure 4: Azimuth versus Elevation (Field Of View FOV) (integrated over time).

The dark area covering $\frac{1}{4}th$ of the field of view is due to the shadow of spacecraft while taking the observations.

MATLAB Program:

```
load('20141128.mat')

%Task 1
S=size(spectra);
s=sum(spectra,2);
s=sum(s,3);
s=sum(s,5);
t=squeeze(s);
figure;
colormap(jet);
pcolor(time,log10(E),double(log10(t')));
datetick('x', 'dd-mmm-yyyy HH-MM-SS');
colorbar;
xlabel('time');
ylabel('log10(E [eV]) ');
title('Log of Spectra');
figure;
colormap(jet);
pcolor(double(log10(t')));
colorbar;
xlabel('time bin');
ylabel('Energy bin ');
title('Log of Spectra');

% Task_2
m=sum(spectra,1);
m=sum(m,2);
m=sum(m,3);
m=squeeze(m);
figure;
colormap(jet);
```

```
pcolor(double(log10(m)));
colorbar;
xlabel('Mass');
ylabel('E');
title('Log of Spectra [Energy_Mass Matrix]');

% Task_4
e = sum(spectra,1);
e= sum(e, 4);
e= sum(e, 5);
e= squeeze(e);
figure
colormap(jet);
pcolor(double(log10(e)));
colorbar;
xlabel('Azimuth');
ylabel('Elevation');
title('Azimuth versus Elevation (Field Of View FOV)');
```