Data Reduction Using the HEASARC Archive and Ftools

- Open Netscape
- Go to HEASARC web page by typing `http://heasarc.gsfc.nasa.gov`
- W3Browse

  On the bottom of the page there are two rows of six locations within HEASARC to which you can go. The top left option is the *W3Browse* location where you can search for observations of various objects.

  - Click on it.
  - Select the *Basic* option.
- Search for a specific object
  - From the *Past Mission Archives* section select *EXOSAT* by clicking on the gray button to its left.
  - In the box at the top labeled *Object Name or Coordinates* enter `GK PER`.
  - Click on *Submit Query*.
- Selecting an observation
  - You will receive many results for this search. Each line in the chart for each section reperesents a separate observation made with the *EXOASAT* satellite.

    Scroll down the page to the section entitled *EXOSAT ME Spectra and Lightcurves (HEASARC_ME)* and click on the gray button to the left of the line of the observation with a quality flag (*qflag_me*) of 4.

The quality flag number corresponds to how good each observation is. 0 is unusable, 1 is very poor, 2 is poor, 3 is acceptable, 4 is very good and 5 is excellent.

- Slightly below the table of observations there is a box, entitled *Categories of data products*, containing different types of data collected in each observation. In the box, click on the second line:

  EXOSAT ME Broadband Lightcurves (BROADLC).

- Click on *Submit.* You may receive a security warning message from Netscape, to continue just click on *Continue Submission.*

- This page shows all the possible data that can be examined from the observation you chose. At the end of each line the filename of the data you wish to retrieve is printed in the form of *file.Z.* Select the lines, toward the bottom, with attached filenames *d05853.lc.Z d05865.lc.Z* by clicking on the gray button to the left of the corresponding line.

- Scroll down the page and click on *Retrieve Data Products*

• Downloading TAR files

  - The screen that appears should list the two files you chose. Click on *Download TAR file* which appears right below.

- The window that appears contains four sections: *Filter, Directories, Files, Selection.* Make sure that **your** directory apears in the *Selection* box. If it does not then you must enter the `/temp` directory you created to store your files.

  If you had to re-enter your directory then when you finished typing click on *Cancel*, then Click on *Download TAR file* again. This time the correct directory should appear in the *Selection* box.

- Click on *OK*

  Netscape will copy the files you have selected into your directory in the form of a *w3browse-#.tar* file. It is a compressed file and cannot be used until it is opened up properly.

- Un-tar your *w3browse-#.tar* by typing:

  `tar -vxf` *w3browse-#.tar*

  This command produced a subdirectory chain in your directory called *me/rates/d/* where youre files are located.

• Organizing and uncompressing the files in your directory

  - You will find the files you downloaded from HEASARC in their new subdirectory by typing:

    `cd` *me/rates/d/*

  - Then type `ls` to list the files.

    d05853.lc.Z d05865.lc.Z should appear.

    Notice the files end with *.Z* . This means they are comrpessed further and still cannot be used.

- Uncompress the files by typing:

  `uncompress *.Z`

  The * is a wildcard character so that your command above says "uncompress **anything** in this directory that ends with *.Z*".

  Then type `ls`. The *.Z* should have disappeared from the filenames making the files usable.

- Remove the *w3browse-#.tar* file now that you have what you need. Type:

  `rm ../../../`*w3browse-#.tar*

- To see the important information about this observation open up one of the files in the emacs editor. Type:

  `emacs d05853.lc` &

  The file that comes up contains information such as the date and time of this observation, the telescope and instrument that collected the data, the location of the object as well as its name.

  Close emacs.

- Examining lightcurves

  - To create a lightcurve for each dataset you will use the *lcurve* routine.

    `type:  lcurve < Enter >`

    Then enter `1` when asked for the number of time series.

  - You will then be queried for the filename you wish to examine. Type: `d05853.lc <enter>`

- You will be asked for the 'window file'. This is a mask that allows you to choose various subsets of the data. Choose `- (dash) <enter>` for the default.
- Now you can bin the data in whatever intervals you wish. For the best time resolution choose the minimum time. In this case, it is:`30 <enter>`
- At this point, you can choose how many intervals you want to look at for this data. Usually, it is most convenient to to have 1 interval (i.e. look at the complete observation as one graph). So choose: `464 <enter>`, which will put 464 "newbins" of 30 sec. each on the graph. This is the entire observation.
- You will now be asked to name the output file. To avoid confusion, I usually choose the same prefix as the input file, and just append a .flc to distinguish it from the original. So type: `d05853.flc <enter>`
- Type: `yes <enter>` when queried about whether you want a plot.

  Type: `/XW <enter>` for the plot device (this is your screen name).

  The lightcurve will now be displayed! To proceed further, you need to move the plot off of the xterm window so you can enter more commands. So drag the graph by the header to a convenient place on the screen.
- At the pgplot prompt, type: `q <enter>` to write the file and exit the lcurve routine.

• Power Spectra!

- To see the periodicities (if any) in the data, you can perform a power spectrum (like a Fourier analysis) on the data. This will tell you the frequencies that contribute to the data you just plotted. So type: `powspec <enter>` to begin this analysis.
- For the filename, you enter the *output file* from lcurve. I.e. type: `d05853.flc <enter>`
- Use the default window file, i.e. type: `- <enter>` Use the minimum Newbin Time for the best power resolution, i.e. in this case, type: `30.  <enter>`
- When asked for the Newbins per interval, choose the Maximum Newbin No. shown, i.e. type: `463 <enter>`. This will allow you to look at the entire observation at once.
- The next parameter asks you about "frames". This allows you to look at segments of several different data sets. For all our analyses, we will always choose 1 interval/frame. So, type `1 <enter>`
- Next, choose 0 (zero) so that you do not rebin the results into different time segments.
- Choose a name for your output file, so you can look at it afterwards. Try (for example): `d05853.pow <enter>`
- Choose yes, to plot the results, and enter /XW for your device name. AND THERE IT IS! Notice the "spikes" that indicate periodic data. You may want to rescale the x-axis to see the plot in better detail. Move the plot off the terminal window and type "rescale x xmin xmax". So in this particular plot, where you are inter-

ested in the exact position of the big peak, you would type: `rescale x 2e-3 3e-3 <enter>`. Incidentally, if you forget any of this, you can type: `help <enter>` to get information about the current routine (in this case, PGPLOT). Type: `q <enter>` to quit pgplot.

  - To examine a hardcopy of the output (to see, say, the exact frequency of the peak) you can run FDUMP. So type: `fdump <enter>` and enter the filename (d05853.pow, for example). If you want to display to the screen, make your output file STDOUT. When you are queried for columns to display, type: `FREQUENCY POWER <enter>`. (If you have another file to examine, you need to find out what those columns are labelled as, so you can do a "more filename" command to examine the header record of the fits file that contains this information.) Now, you can see the results of the graph. Note that the maximum of the power spectrum is at: 2.865 e-3 Hz = 349 seconds, the period of GK Per.

- CONCATENATION OF FILES

  - After you do the separate analysis of the entire observation, consisting of 05853 and 05865 segments, you will want to put them together. This you do by entering a file list, in place of the individua filenames in it lcurve. So you would create a file, say, it list.con and it would just two lines in it:

    d05853.flc

    d05865.flc

    Note that the INPUT files to *list.con* are the .flc files!!

Now, when you run *lcurve* you enter @list.con in place of the filename you used previously. Your other parameters will also change, because you are now dealing with 900+ bins instead of 400+. Then, you can executeb *powspec* on the summed data.