An Introduction to Ftools
A
Project
on
Statistics and Computer Course

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Introduction

➢ FTOOLS is a software package provided by NASA to use in High Energy Astrophysics Research.

➢ FTOOLS is used for analyzing FITS. FITS stands for "Flexible Image Transport System" and is the standard astronomical data format endorsed by both NASA and the IAU. FITS is much more than an image format (such as JPG or GIF) and is primarily designed to store scientific data sets consisting of multi-dimensional arrays (1-D spectra, 2-D images or 3-D data cubes) and 2-dimensional tables containing rows and columns of data.

Installation

➢ In order to download it, go to HEASARC (High Energy Astrophysics Scientific Archive Research Center) website *www.heasarc.gsfc.nasa.gov/* .

HEASARC

**High Energy Astrophysics
Science Archive Research Center**

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Search the HEASARC site: enter text

The HEASARC is an archive of astronomy data from extreme ultraviolet, X-ray, and gamma-ray observatories. On this site, you'll find archival data, multi-mission software and analysis tools, information about current and past observatory missions, and information for educators and the public.

- More about the HEASARC
- Frequently Asked Questions

Latest News

- New Browse: **version 7 released** (30 Jan)
- *Imagine News:* A Neutron Star Emerges As A Rare Magnetic Emerald (28 Jan)
- NVO service hosted by HEASARC: Search 12 Data Archives with one click! (21 Jan)
- *Imagine News:* Einstein Makes Extra Dimensions Toe The Line (17 Dec)
- Proposals: **Chandra Cycle 6 Call for Proposals** released (16 Dec)
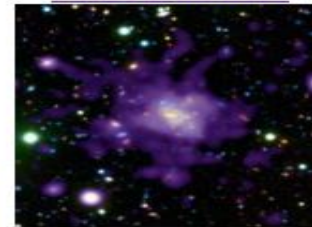- Analysis Software Update: **HEASOFT 5.3** released (25 Nov)
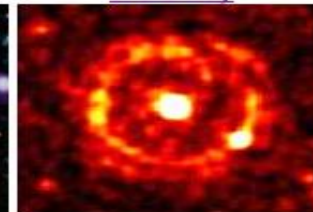
More News

Latest Gamma-Ray Bursts

GRB031220: GCN Circ archive: HETE, optical, IR
GRB031203: GCN Circ archive: INTEGRAL, optical, IR, x-ray, radio

Gamma-ray burst Coordinates Network Circulars Archive

**HEASARC
Picture of the Week**

**Astronomy Picture
of the Day**

Browse the Archive

Education & Public Outreach
- StarChild (Grades K-8: general astronomy)
- Imagine the Universe (Grades 7-12: high-energy astronomy)
- X-ray and Gamma-ray images of celestial objects
...and more

Is my favorite object an X-ray, gamma-ray, or EUV source?

enter source name

Frequency Regime: X-Ray ▼   Submit

➢ Software>Ftools>Ftools 6.12>Download HEASOFT>Step 1-Source code distribution>PC - Linux – Ubuntu>Step 2-Download the desired packages> All>Submit.

➢ Installation guide is given it the website itself.

➢ Once we installed it, our environment will change to ftools when we type "**heainit**".

➢ After installed it, if we want to check whether the installation has no error, just type "**heainit**" and then "**lcurve**" or "**powspe**c" etc.

➢ Now we need to download data from HEASARC website. First we have to choose an object knowing the name, co-ordinate and which satellite took the observation in what time interval.

Plotting Light Curve

➢ Once we download the data, we can first plot the light curve. The curve that shown us the variation of count/s with time is called light curve.

➢ In order to plot light curve, we must know where the file is located. Go to "**terminal**" change the directory to the folder that contained the file.

➤ Then type "**heainit**" to initialize ftools>**"lcurve"> "file name"**.

```
pulsar> lcurve

lcurve 1.0 (xronos5.18)

Number of time series for this task[1]1

Ser. 1 filename +options (or @file of filenames +options)[file1] cenx-3_long.lc
 Series 1 file   1:cenx-3_pca.lc
```

➤Here it asks for total numbers of time series/light curves and corresponding file names. Maximum up to 4 time series can be given to get their ratio, sum etc.

```
Selected FITS extensions: 1 - RATE TABLE;

Source ........... CEN_X-3           Start Time (d) .... 10507 00:19:27.562
FITS Extension .... 1 - `RATE    `   Stop Time (d) ..... 10510 19:57:03.562
No. of Rows .......      1873744      Bin Time (s) ......   0.1250
Right Ascension ... 1.70313293E+02   Internal time sys.. Converted to TJD
Declination ....... -6.06232986E+01  Experiment ........ XTE        PCA

Corrections applied: Vignetting - No ; Deadtime - No ; Bkgd - No ; Clock - Yes

Selected Columns:  1- Time;  2- Y-axis;  3- Y-error;  4- Fractional exposure;

File contains binned data.
```

➤ After reading the light curve, it displays summary of the observation e.g. name of the source, position of the source, start and stop time of the observation, time format and bin time of the observation, what type of corrections are applied to the light curves etc.

➢ In all XRONOS tasks, a window file is used for filtering data, if required. Various windows such as time window, phase window, intensity window or exposure window can be applied. Here we will use the default window ('-').

```
Name of the window file ('-' for default window)[-] -
Expected Start ... 10507.01351345407  (days)          0:19:27:562  (h:m:s:ms)

Expected Stop .... 10510.83129123185  (days)         19:57: 3:562  (h:m:s:ms)

Minimum Newbin Time    0.12500000       (s)
for Maximum Newbin No..            2638849

Default Newbin Time is:    645.00587    (s) (to have 1 Intv. of      512 Newbins)
Type INDEF to accept the default value

Newbin Time or negative rebinning[4.6692607009327] 3600
```

➢ Here we specify the required new bin time in seconds. This is a long observation and hence we are rebinning the light curve with bin size of 1 hour.

```
Newbin Time ......      3600.0000      (s)
Maximum Newbin No.                92

Default Newbins per Interval are:        92
(giving        1 Interval of          92 Newbins)
Type INDEF to accept the default value

Number of Newbins/Interval[10] 92
 Maximum of        1 Intvs. with          92 Newbins of        3600.00      (s)
```

➤ An Interval, in XRONOS terminology, is defined as the number of newbins over which the analysis is carried out. Here there are 92 newbins available and we include all of them in one interval. It is also possible to specify less no. of newbins and is very useful when we want to analyze small parts of the light curve separately.

```
Name of output file[default] test
Do you want to plot your results?[yes] yes
Enter PGPLOT device[/XW] /xw
    92 analysis results per interval

 100% completed

PLT>
PLT> line step
PLT> plot
```
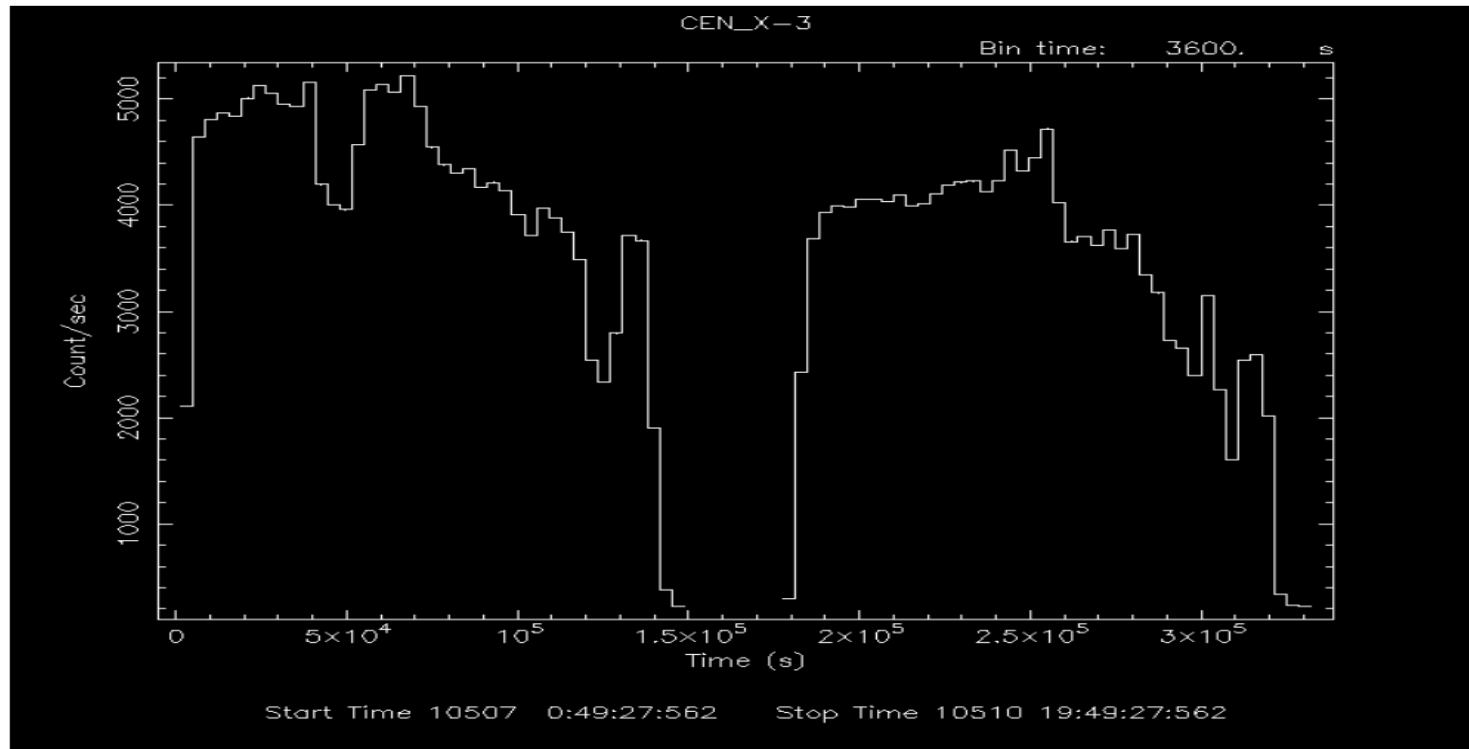
➢ Finally, it asks for the file name to save the rebinned file and whether to plot the result or not. All XRONOS tasks use QDP/PLT to plot the results, which is a general purpose plotting and function fitting program.

➢ But individual pulses are not visible in this plot because pulse period is about 4.8 second which is much smaller than our bin time of 1 hour.

Finding period by Fourier analysis

➢ Now we want generate a Power Density Spectrum (PDS) from this light curve in order to find out its pulse period. The XRONOS package has a task named "**powspec**" , which generates the Fourier spectrum or PDS of a light curve. You already have the light curve file cenx-3_pca.lc in your directory.

➢ To start this, write "**powspec**" in the terminal and will display as below

```
pulsar> powspec

powspec 1.0 (xronos5.18)

Ser. 1 filename +options (or @file of filenames +options)[file1] cenx-3_pca.lc
 Series 1 file    1:cenx-3.lc
```

```
Default Newbin Time is:  1.0000000     (s) (to have 1 Intv. of    8192 Newbins)
Type INDEF to accept the default value

Newbin Time or negative rebinning[4.66926070093271] 0.125
```

➢ A warning will be shown saying that "Newbin Time must be an integer multiple of Minimum Newbin Time". This is a requirement of powspec.

```
Newbin Time ......    0.12500000      (s)
Maximum Newbin No.             60000

Default Newbins per Interval are:      8192
(giving       8 Intervals of       8192 Newbins)
Type INDEF to accept the default value

Number of Newbins/Interval[10] 8192
Maximum of      8 Intvs. with       8192 Newbins of      0.125000     (s)
```

➢ There is one more requirement of powspec, that total number of newbins per interval should be an integer power of 2. Here we shall accept the default 8192 newbins per interval. This will give total 8 intervals i.e. the analysis will be carried out on 8 independent segments of the light curve each of 8192 bins. However, since total number of newbins are not multiple of 8192, the last segment will be half empty and we shall use only first 7 full segments.

```
Default intervals per frame are:        1
Type INDEF to accept the default value
Number of Intervals/Frame[1] 7
 Results from up to       7 Intvs. will be averaged in a Frame
```

➢ A frame is made by averaging results of the analysis of one or more contiguous intervals. Here we average 7 intervals in one frame and discard the last interval.

```
Rebin results? (>1 const rebin, <-1 geom. rebin, 0 none)[0] 0
```

➢ Now we are not rebinning in this case.

```
Name of output file[default] test
Do you want to plot your results?[yes] yes
Enter PGPLOT device[/XW] /xw


PLT> r x 0.05 5
PLT> log x on
PLT> plot
```
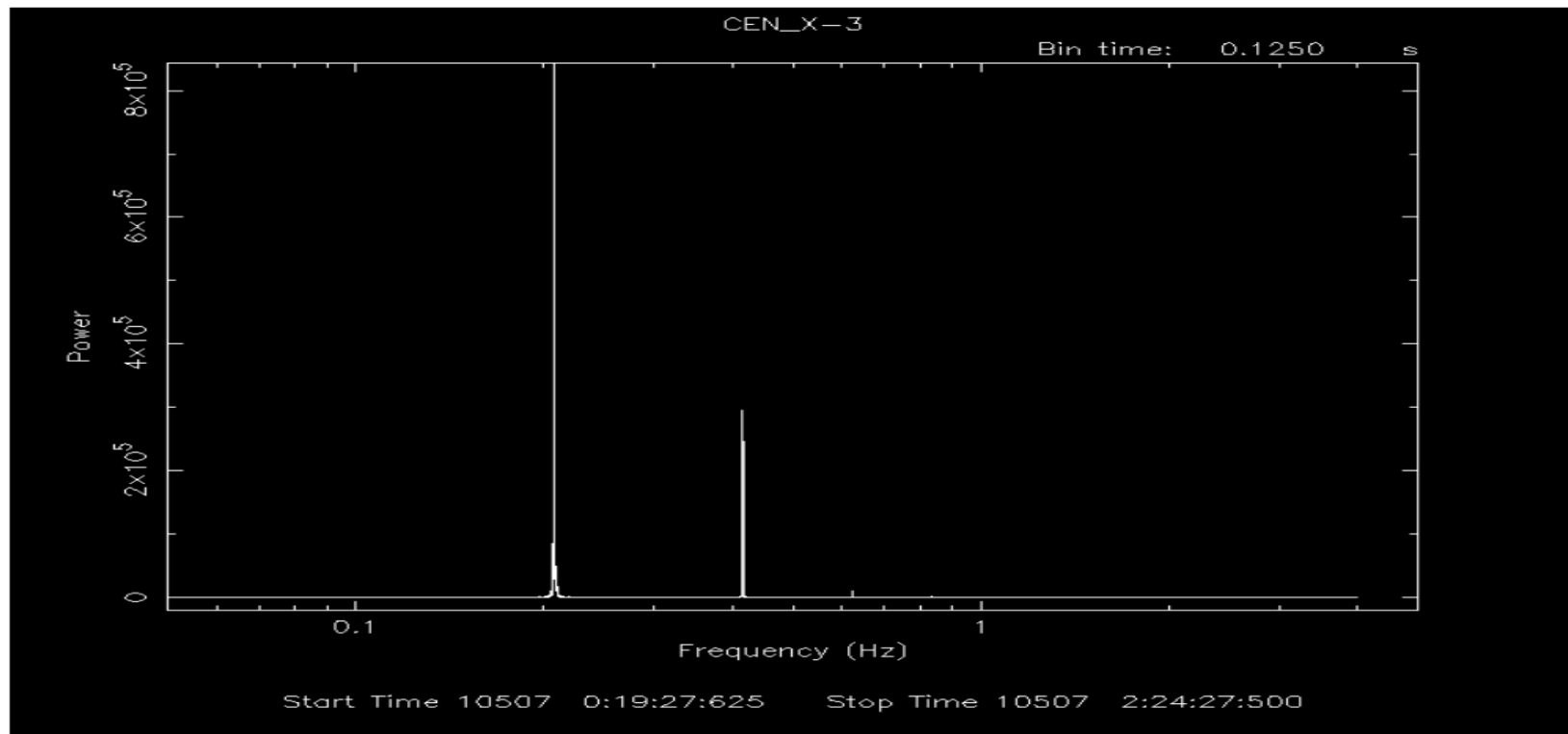
➢ The prominent peak corresponds to the pulse period whereas the second peak corresponds to the first harmonic of the period.

Finding period by Epoch folding

➢Here we are going to determine the pulse period for the same source using light curve folding method. This method is very useful to find out accurate period if an approximate period is known. The XRONOS package has a task named efsearch which folds the light curve with large number of periods around the approximate period and finds the best period by chi square maximization.

➢ To initialized type "**efsearch**", and the following picture will display.

➢ Epoch is the reference point with respect to the what the light curve is folded. Here we accept the default value, which is the starting point of the light curve. We give the approximate period (obtained using power density spectrum?) and the period derivative or the change in period with time, which, in our case is zero.

```
pulsar> efsearch

efsearch 1.1 (xronos5.18)

Ser. 1 filename +options (or @file of filenames +options)[cenx-3.lc]cenx-3_pca.lc
 Series 1 file    1:cenx-3.lc

 Selected FITS extensions: 1 - RATE TABLE;

 Source ............ CEN_X-3              Start Time (d) .... 10507 00:19:27.562
 FITS Extension .... 1 - `RATE      `     Stop Time (d) ..... 10507 02:24:27.559
 No. of Rows .......        60000         Bin Time (s)......     0.1250
 Right Ascension ...                      Internal time sys.. Literal
 Declination .......                      Experiment ........

 Corrections applied: Vignetting - Yes; Deadtime - Yes; Bkgd - Yes; Clock - Yes
            values: 1.00000000       1.00000000      1.00000000

 Selected Columns:  1- Time;  3- Y-axis;  4- Y-error;  5- Fractional exposure;

 File contains binned data.

Name of the window file ('-' for default window)[-] -

 Expected Start ... 10507.01351345407  (days)        0:19:27:562  (h:m:s:ms)
 Expected Stop .... 10507.10031897535  (days)        2:24:27:559  (h:m:s:ms)

 Default Epoch is:  10507.00000
Type INDEF to accept the default value
 Epoch format is days.
Epoch[10507.00000] 10507.00000
 Period format is seconds.
Period[5.0] 4.8
Period derivative        [0] 0
 Expected Cycles ..            1562.50
```

```
Default phase bins per period are:        8
Type INDEF to accept the default value
Phasebins/Period {value or neg. power of 2}[16] 16

Newbin Time ......    0.30000000        (s)
Maximum Newbin No.            25000

Default Newbins per Interval are:       25000
(giving        1 Interval of        25000 Newbins)
Type INDEF to accept the default value

Number of Newbins/Interval[25000] 25000
Maximum of        1 Intvs. with        25000 Newbins of        0.300000     (s)
```

➢ Here we divide each pulse in 16 phases i.e. each newbin will be one sixteenth of the pulse period or 0.3s .

```
Type INDEF to accept the default value
Resolution for period search {value or neg. power of 2}[0.01] 0.0001
Default number of periods is       128
Type INDEF to accept the default value
Number of periods to search[4096] 4096
```

➢ Here we specify total number of periods and resolution for the period search. We are asking it to fold the light curve with 4096 different period separated by 0.1ms around the approximate period of 4.8s.

```
Name of output file[default]
Do you want to plot your results?[yes]
Enter PGPLOT device[/XW]

    4096 analysis results per interval

  Chisq. vs. period ready

  Period :   4.809   dP/dt :   0.000
  Intv    1   Start 10507  0:19:27
     Ser.1     Avg  3257.      Chisq 0.7471E+07   Var 0.3719E+07 Newbs.
16               Min  1177.       Max  7050.    expVar  7.966      Bins
52320
PLT>
```
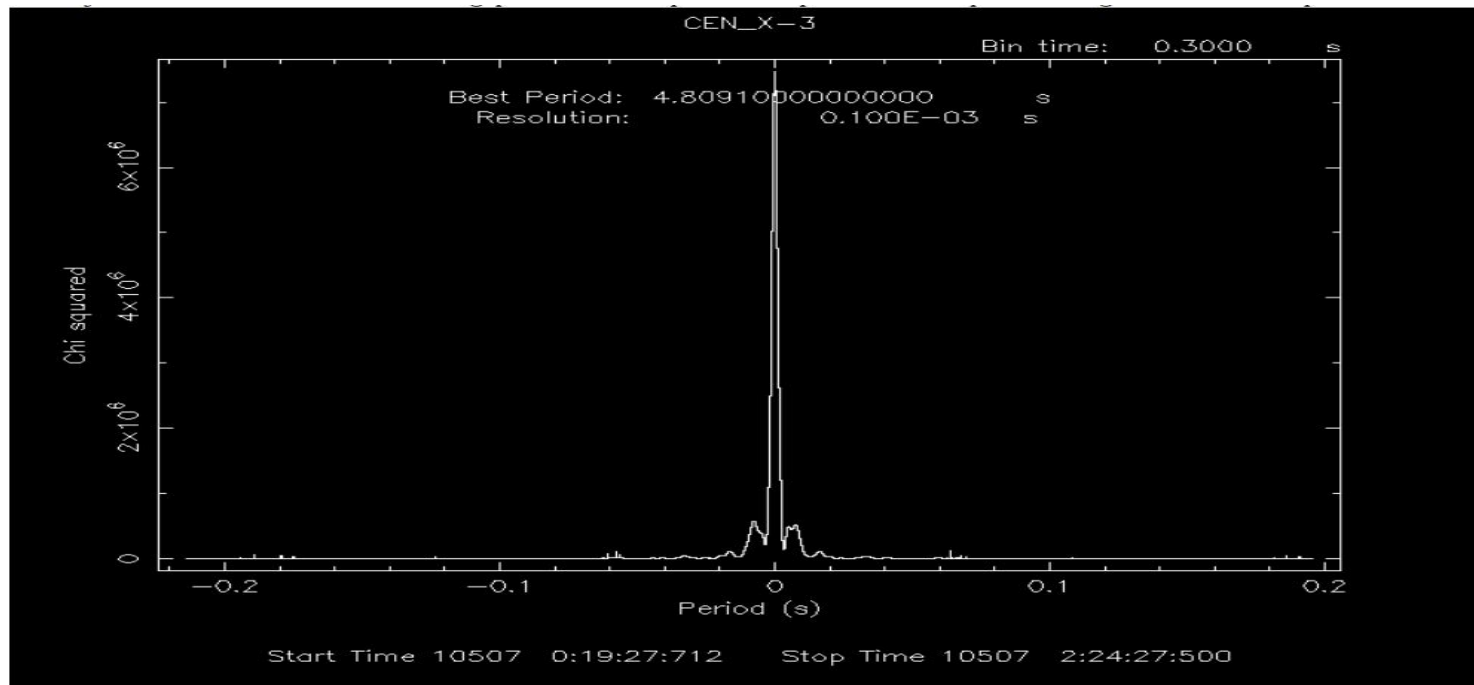
➤ Further analysis may find the period change which is due to losing energy from the rotating pulsar in the form of radiation.
➤ Once we find the period change, we can determine the surface magnetic field strength etc.

Thank you