Manual for Period98 : V1.0.1 A period search-program for Windows and Unix

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Contents

Copyright notice

1. Introduction

1.1 What is Period98 ?

Period98 is a program to search for and fit sinusoidal patterns within a time series of data in which one suspects periodic behavior.

This kind of data sets commonly occur in observational science such as astronomy (light curves of stars), meteorology (daily temperature measurements) or physics.

Period98 has been written to solve problems of large astronomical data sets containing huge gaps. But as mentioned earlier, in other fields such data also occur and thus often a similar approach can be taken. So even though most examples are taken from astronomical data the basics will apply to all kind of data, even if these are from an entirely different field.

Some commonly used techniques to solve such problems are:

- Minimization of residuals of sinusoidal fits to the data
- Fourier analysis and Fast Fourier analysis
- Clean
- Wavelet
- Maximum entropy
- Phase dispersion minimization
- etc.

Many thanks to Julian Smart and Markus Helmholz for the wxWindows GUI library.

2. Installing Period98

2.1 Microsoft Windows95 and Windows NT

To install **Period98** on Windows95 or Windows NT you have to get the file P98inst.exe (ftp://dsn.astro.univie.ac.at/pub/Period98/current/P98inst.exe) and start it. This will lead you through the setup procedure and finally installs **Period98** on the start menu.

2.2 Unix - Install precompiled

The following UNIX executables are currently (or will shortly be) available:

- i386 - Linux (ftp://dsn.astro.univie.ac.at/pub/Period98/current/Period98-1.0.1-linux)
- Alpha - OSF1 (ftp://dsn.astro.univie.ac.at/pub/Period98/current/Period98-1.0.1-osf)

To review the latest list of compilation of **Period98** executable packages please have a look at the Period98 homepage (http://dsn.astro.univie.ac.at/period98).

To install, simply type the command: `sh Period98-1.0.1-<OSTYPE>` as this is a shell script. You will be asked a few questions about where to install the relevant files. First where all the files needed for **Period98** should be installed, and then where the binary itself should be installed.

When the program has finished, **Period98** is ready to use and can be started with the command: `Period98` .

2.3 Unix - Install from source code

To install **Period98** from source code you must have the following programs installed on your computer:

- C++ compiler (preferably GNU-gcc 2.7.2 or later, others may not work)
- gzip
- possibly GNU-make

2.3.1 What files are needed

Please get all of the following files:

- wxxt-GUI-library: wxxt-1.66.tgz
  (ftp://dsn.ast.univie.ac.at/pub/wxwin/wxxt-1.66.tgz)
- wxxt-GUI-library utils: utils.tgz
  (ftp://dsn.ast.univie.ac.at/pub/wxwin/utils.tgz)
- Period98 sources: Period98-1.0.1.tgz
  (ftp://dsn.astro.univie.ac.at/pub/Period98/current/Period98-1.0.1.tgz)

2.3.2 Compiling Period98

- Extract files for compilation
  - extract the file **wxxt-1.66.tgz** with the command:
    `zcat wxxt-1.66.tgz| tar xf -`
  - enter the directory **wxxt-1.66** with:
    `cd wxxt-1.66`
  - extract the file utils.tgz with the command:
    `zcat ../utils.tgz| tar xf -`
  - enter the directory **user** with:
    `cd user`
  - extract the file **Period98-1.0.1.tgz** with the command:
    `zcat ../../Period98-1.0.1.tgz| tar xf -`
  - enter the directory **Period98** with:
    `cd Period98`
  - go back to the **main** directory with:
    `cd ../..`

- Configure your system with the command:
  `./configure`
  If this does complain about something, then please try to fix the situation according to the messages that you receive.
  The most probable events may be that the version of **make** installed on your machine does not support some features needed to compile or that your shell does not define the system variable OSTYPE.

- Compile the relevant components with the command:
  `make all SRC="src utils/wxTab utils/wxHelp user/Period98"`
  in the case of compile or link problems that mention something about xpm please retry to configure your system with the additional switch: `--without-xpm`, then type `make clean` and then start compiling anew.

- Create an installable executable package of **Period98** with the command:
  `./Period98Package`

This will create a file called Period98-1.0.1-<OSTYPE>. This is a final distributable file for your system.

- Install the package as explained to you in: **Installing precompiled binaries** (section 2.2) .

After some tests with the newly compiled **Period98** we would welcome if you could send us a copy of your compiled **Period98** . To do so please upload to the Period98 incoming directory (ftp://dsn.astro.univie.ac.at/incoming) and send a mail to period98@dsn.astro.univie.ac.at, so that we may include it, along with other binary distributions for the convenience of other potential users.

3. Using Period98

As from the early design stages, the philosophy for **Period98** had been usability and scientific reproducibility. Therefore its central feature is its **project file**. This offers the possibility to stop at a certain point and continue later - maybe even on a totally different operating system - as if the program had not been stopped.

Along with this comes the **log feature**, where every action that has been taken is written down with the current date and time. This log also offers the possibility to include comments, thoughts, etc. with the machine generated ones. The design goal for the **log** had been that it can be read easily by the human user. Beware, as the program generated documenting messages are quite extensive even a simple session can produce large output - this can be a real nuisance but can also help in some cases!

All the other parts of **Period98** are attached as modules to this backbone.

The most essential module is the one for handling the **time string data**. It offers the possibility to select different parts of the time string. Thus each and every data point can have up to 4 different **attributes** that can be attached to it. With these attributes, which are named by default: *Date*, *Observatory*, *Observer* and *Other*, each data point can have a label of its own. With this it is easy for example to differentiate between days, observers or observatories - even techniques or different instrumentation.

An example for a data point is:

time	116.7018519
amplitude	11.231
date	1996-02-03
observatory	SAAO
observer	Smith

and the format of the data would be:
`116.7018519 11.231 1996-02-03 Keck Smith`

Thus selecting a certain subset of the time string can be done by selecting the appropriate labels in each of these attributes.

> **Note:** A point is only added to the current selection if **all** its attributes are selected.

These qualities also offer common additional attributes except for their name, namely:

- **color**: this helps to differentiate between different attributes in a graph.
- **weight**: this gives, as a product of the weight of all qualities for a certain

point, a weight to the point. This value then can be used by all the other modules when performing calculations.

Finally there is the concept of **uncorruptable data**, which means, that the original data should not be shifted, scaled, etc. in any way. So there are two distinct sets of amplitudes for each data point:

- **original**: the unedited data
- **adjusted**: the edited data, which can easily be reverted to the original values.

> **Note:** Again, as **Period98** never wants to change original data, the deletion of data is not an act of deleting but an act of changing a certain attribute to "deleted" for example. (This label can be changed.)

The next module is only responsible for **sinusoidal fits** to the currently selected time string. It basically consists of a table of frequencies, amplitudes and phases along with a zero point.

The fit to the data is as follows:
$A(t) = Z + \sum A_i sin(2\pi(tF_i + P_i))$

Frequencies can be active or inactive for a certain fit, giving more degrees of freedom to the user. The user may check different solutions to the same time string, or look for effects of certain frequencies on a Fourier spectrum.

Additional features are that a frequency can either be a **harmonic** of another frequency (which helps fitting data with nonsinusoidal shapes) or a **combination** of two other frequencies (sum or difference of integer multiples of each frequency).

Fits to the data are allowed with almost arbitrary freedom, but basically there are 3 modes of calculation:

- **Calculate**: keeps the frequencies fixed and finds the best fit for all selected amplitudes and phases.
- **Improve**: improves the frequencies as well.
- **Special**: gives full choice of what frequencies, amplitudes and phases should be improved, as well as a possibility to calculate **amplitude and/or phase variations** according to a certain attribute of the time string.

The last of the modules of **Period98** gives access to **Fourier** techniques. In this case there is nothing much out of the ordinary, but it has some interconnections with the **fit** module.

> **Note:** it performs full featured Fourier transformation and does not use the faster "Fast Fourier Transform "(FFT) algorithm, as data do not have to be equally spaced.

For bookkeeping, the result of the Fourier calculations are stored together with the project as long as these are not removed by the user. Each calculation also has a label of its own for ease of recognition.

One special feature is the possibility to calculate a Fourier spectrum with *weighted* data, or the possibility to calculate **Fourier noise**. This means calculating an average amplitude for a certain frequency range. It can be very useful to determine if an peak is significant or not.

3.1 Starting up Period98

Starting **Period98** is as easy as:

- typing `Period98` under Unix(tm)
- Starting **Period98** from the start menu under Windows 95(r), or Windows NT(r)

3.2 A small example

3.2.1 Reading in a time string

First we have to load a time string. To do so, please go to the **time string folder** (section 4.2.1) and press the **"Import"** button in the bottom of the window. Then you will be asked for the name of the file you want to import. Please select the file `test.dat` in the samples directory of the **Period98** installation directory (the exact location depends on your installation, but it should be installed in the directory "samples" of the installation directory of **Period98**).

Then you will see that the **import dialog window** (section 4.2.2) will show up. For the moment please just click on the **"Ok"** button, as the defaults are acceptable. For further information please check out the reference above.

As you can see, the window has changed and some further information is given, e.g. the number of points selected and the total number of points.

To have a look at the data please press on the **"Display Graph"** button. This will open up a window with the representation of the timestring. (See **timestring graph window** (section 4.2.9) for more details.)

You already can see some periodicity in the graph itself, so let us try to find out what frequencies are in the data.

3.2.2 Fourier analysis

First we have to make a Fourier analysis. Activate the **fourier folder** (section 4.4.1) by clicking with the Mouse on **Fourier** - but do *not* select the menu.

The new dialog offers a lot of possibilities, but as the defaults for **Period98** are well chosen in this case just pressing on the **"Calculate"** button will start the calculation.

But before starting the calculation **Period98** will ask if it should subtract an average zero point of -0.007892. (For more detailed discussion please see **Fourier zero point** (section 4.4.3) .) Please choose yes as well and then the calculations will start.

When the calculation has finished, a small window will show up and ask, if you want to include the frequency with the highest peak. (The result should be:

Frequency of 11.9162641 and an amplitude of 0.10172852). Please choose again yes and this frequency will be included in a list of frequencies.

The Fourier spectrum can also be examined graphically by pressing on the **"Display graph"** button. The new **window opening up** (section 4.4.6) will display the result.

Note: As you may notice the graph is not smooth. This is due to the fact that during Fourier calculation **Period98** tries to minimize memory usage by memorising only local extrema and skipping all the points in between.

3.2.3 Fit one frequency

So, as we have got a frequency, we can try to fit it to the signal. Activate the **fit folder** (section 4.3.1) by clicking with the Mouse on **Fit** - but not on the menu.

As we have already included one frequency, we can see its parameters in the table as F1. As the frequency F1 has not been activated, please tick the checkbox in front of **F1** to activate it.

Now, at first we have to find out about the true phase using the least square fit technique. Just press on the **"Calculate"** button and almost immediately the window will be updated with the new values.

frequency	**amplitude**	**phase**
11.9162641	0.100150376	0.0200245
zero point	0.00101803983	
residuals	0.0342341403	

But the frequency itself has not been improved. And this is what we actually want to do. So press now on the **"Improve all"** button. This will also improve the frequency and should give the following result:

frequency	**amplitude**	**phase**
11.9870449	0.101277217	0.00447894
zero point	0.00224986037	
residuals	0.0336615961	

This is the best fit that we can reach with a single frequency.

3.2.4 Fourier analysis with residuals

Now go back to the **Fourier folder** and select the "Residuals at original" entry in the "Calculation based on" item. Then calculate Fourier anew by pressing the **"Calculate"** button.

This time you should not be prompted for a zero point, as **Period98** assumes that the residuals have a mean value of zero. The fit should already have taken care of it.

Again please include the frequency of the highest point, which in this case should be: Frequency= 7.16586151 and amplitude: 0.0457409859.

3.2.5 Fit two frequencies

Now we have found two frequencies, so let's go back to the **Fit folder** and activate the frequency F2 as well. Then press again the **"Calculate"** button.

After the calculations have finished, the window will be updated with the new values:

frequency	**amplitude**	**phase**
11.9870449	0.0975994208	0.00428761
7.16586151	0.0479167213	0.25244
zero point	-0.00198521031	
residuals	0.00645800843	

Finally improve the frequencies as well by pressing on the **"Improve all"** button, and the window will be updated with the new values:

frequency	**amplitude**	**phase**
11.9994309	0.100072311	0.000117863
6.99670604	0.0501719796	0.301063
zero point	1.50619639e-05	
residuals	0.000281511948	

This is very close to the values chosen for creating the artificial light curve, which are:

frequency	**amplitude**	**phase**
12	0.1	0.0
7	0.05	0.3
zero point	0.0	
residuals	0.000329267906	artificial noise

3.2.6 Save the Project

Finally we may want to save the full results. To do so, please select the *menu entry "Save Project"* from the *menu "File"*, and save the project.

Period98 can be quit by selecting the *menu entry "Quit"* from the *menu "File"*.

To continue with all the settings that you have had in your last session restart **Period98** and then select the *menu entry "Load Project"* from the *menu "File"*. Now you can continue as if the work has not been interrupted.

4. Period98 in detail

4.1 Basics

4.1.1 The main window

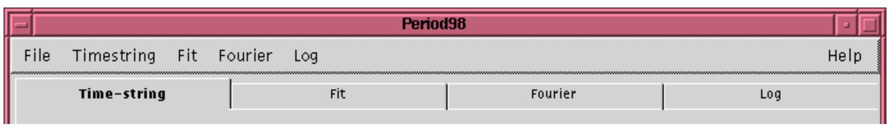


Figure 4.1: The top part of the main window of **Period98**

When starting **Period98** is the main window will be shown. In the **top** (figure 4.1) there is a menu bar and below 4 folders labeled as:

- **Time string** (section 4.2) ,
- **Fit** (section 4.3) ,
- **Fourier** (section 4.4) and
- **Log** (section 4.5) .

Each of these can be clicked to enter the relevant folder.

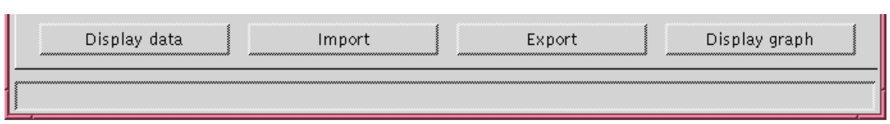


Figure 4.2: The lower part of the main window of **Period98**

In the **bottom** (figure 4.2) there are 4 buttons (which may not necessarily be present in every folder) and which trigger different actions, depending on the currently active folder:

- **Display data**: opens a window with a table of data.
- **Import**: allows to import data from other sources.
- **Export**: allows to export data as a single file.
- **Display graph**: opens a window with a graph of data .

Below there is the status bar, which will give you additional information about the current menu entry.

4.1.2 Project

The main control for the project lies in the *menu "File"*. (See **File menu** (figure 4.3)

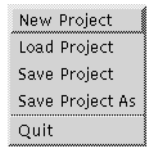


Figure 4.3: The "file" menu

There are 4 menu entries. The *menu entry "New Project"* erases the current project from memory after a user confirmation and sets all values to their defaults.

The *menu entry "Load Project"* will load a project file, while the *menu entry "Save Project"* will save the project file with the same name, as it had been loaded. If the project was started anew, the user will be prompted for a new filename. Finally the *menu entry "Save Project as"* allows to save the project with a different name.

The *menu entry "Quit"* will exit **Period98** . If the Project has not been saved first, the user will be asked for confirmation.

4.1.3 Help menu

The *menu "Help"* gives the user additional information on **Period98** .

Figure 4.4: The "help" menu

There are a some menu entries:

- **About** will inform about the version of **Period98** .
- **Copyright** will start the help system and display the copyright message for the **Period98** manual.
- **Introduction** will start the help system and display the Introduction section of the **Period98** manual.
- **Contents** will start the help system and display the contents section of the **Period98** manual.
- **Keyword search** will start the help system and allow to search for a certain keyword in the **Period98** manual.

4.1.4 In case of a program error

In case of a program error **Period98** will try to recover from the worst, inform the user that an fatal error has occurred and ask for a filename to store the current project.

Note: A new filename is preferred, as the internal data structure may already have been destroyed and thus the output may be garbled.

4.2 Time string

4.2.1 Time string folder

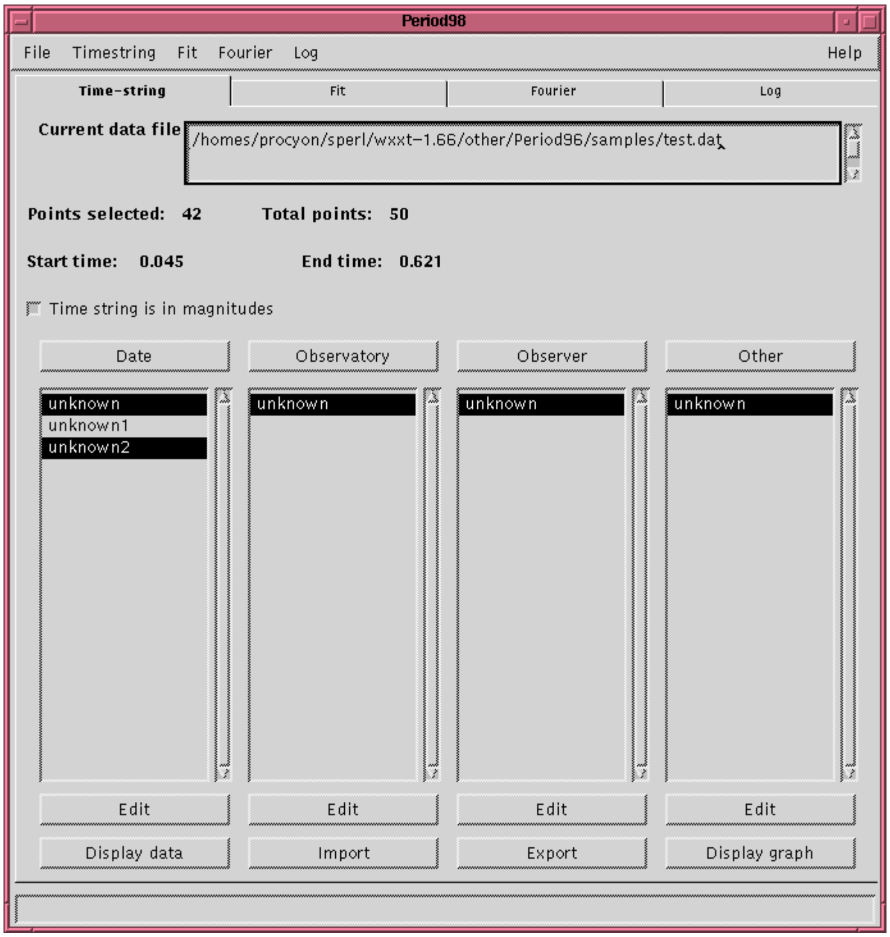


Figure 4.5: The "time string" folder

This folder shows all the required information regarding the time string.

Current data file: gives the full pathname of the files from which the data have been imported.

Points selected: gives the number of points that are selected.

Total points: gives the total number of points in the time string.

Start time: gives the start time of the selected timestring.

Time string is in magnitudes: informs Period98 that the timestring is in magnitudes (i.e. the scale is inverted for plots, etc...)

End time: gives the end time of the selected timestring.

There are **4 list boxes with buttons on top** side by side, each of which represents one attribute of the time string.

Please note that the identifiers for each attribute can be changed to fit the requirements by pressing on the button on top of each list box.

Edit Buttons below the list boxes: these allow changes to some settings in the currently highlighted labels of an attribute - i.e: this allows changes to the weight and color of this label. See also **Edit label** (section 4.2.7) .

The 4 Buttons in the bottom have the following meaning:

- **Display data**: Displays the selected time string with the full information regarding residuals, attribute, weights, etc. in a **window** (section 4.2.8) .
- **Import**: Imports a time string from file. See also **Import Time string** (section 4.2.2)
- **Export**: Exports the selected time string to a file. See also **Export Time string** (section 4.2.3)
- **Display Graph**: Displays the selected time string in a **window** (section 4.2.9) with the current fit.

4.2.2 Import time string

There are the following possibilities to import a time string:

- the **"Import"** button is pressed in the time string folder
- the *menu entry "Import time string"* in the *menu "time string"* has been selected
- the *menu entry "Append time string"* in the *menu "time string"* has been selected. In this case the old time string does not get erased but the next time string is appended to the current one.

A common file selector dialog will open up to select a file to import. Then the file is parsed for its contents and finally the **Import format dialog** (figure 4.6) is opened.

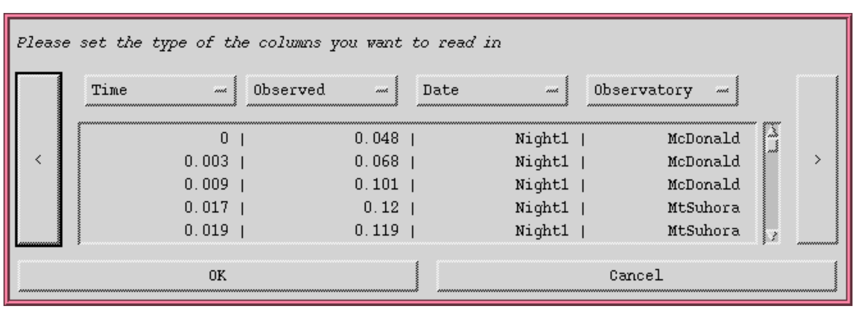


Figure 4.6: The "import format" dialog

This dialog lists the first few lines of the time string to read in and shows them along with some defaults for each column, guessed from the structure of the data in the file. Only 4 columns are displayed at every given time, but scrolling is achieved by pressing the buttons to the left and right of the list box.

Heading each column is a choice item with the following possibilities:

- Time
- Observed
- Adjusted
- Residuals to Observed
- Residuals to Adjusted
- Calculated
- Per point weight
- Attribute 1 - depending on the label given
- Attribute 2 - depending on the label given
- Attribute 3 - depending on the label given
- Attribute 4 - depending on the label given
- ignore

These can be changed to reflect the actual data to read in. Thus it is possible to ignore certain columns or to read in strangely formatted files.

Note: Please note that lines starting with "#", ";", "%" are assumed to be comment lines and are ignored!

4.2.3 Export time string

To reexport the *selected* time string there are two possibilities:

- the **"Export"** button is pressed in the time string folder
- the *menu entry "Export time string"* in the *menu "time string"* has been selected

This time the output file format is specified using a multiple selection list in the **export format dialog** (figure 4.7) .

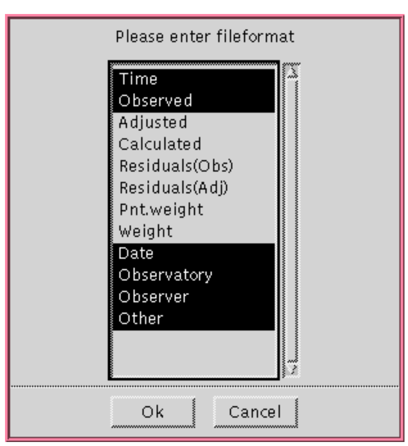


Figure 4.7: The "export format" dialog

This way it is possible to extract only certain parts of the full information that each point contains.

Note: In this case the sequence is predetermined and always top to bottom. After pressing OK, a dialog to save to file will be shown.

After pressing the **"Ok"** button a dialog to save to a file will be shown.

Note: As a final note: The time string will be written out in the same sequence as it had been read in. So reading in unsorted data and re-exporting it again will not result in a sorted time string.

4.2.4 Combine substrings

It is possible to combine the selection and to give it a common attribute. To do so, the *menu entry "Combine substrings"* in the *menu "time string"* has to be selected.

The **Combine substrings dialog** (figure 4.8) , which opens up gives the possibility to enter a new common label and select which attribute the label should belong to.

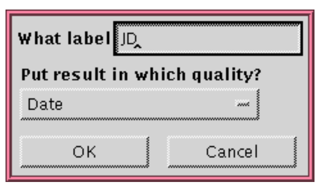


Figure 4.8: The "combine substrings" dialog

4.2.5 Subdivide selection

Often a time string contains gaps due to a specific observational pattern. In this case, **Period98** offers the possibility to split a currently selected time string into subsets by finding gaps that fulfill a requirement and splitting it up there.

To do so the *menu entry "subdivide time string"* in the *menu "time string"* has to be selected. Then the **subdivide selection dialog** (figure 4.9) will be displayed and the relevant data for this operation can be entered:

- **minimum size of gap** between 2 consecutive points at which to make a subdivision.
- what **attribute** the separations should belong to.
- what is the **label prefix** from which to create a final label.
- should a **running counter** or the integer part of the time of its first new element be added to the label prefix to give the resulting label.

Note: To reconvert the subdivided timestring, removing all the generated labels and replacing them with a new common one, the **Combine substrings** (section 4.2.4) option should be used. A new label should be entered and as attribute the attribute where all the split labels are should be entered.

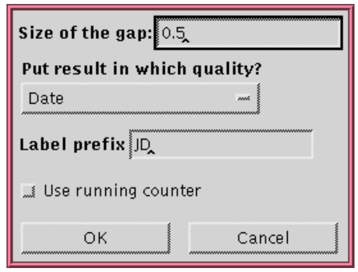


Figure 4.9: The "subdivide selection" dialog

4.2.6 Adjust selection

Often different subsets of data can have marginally different zero point offsets, which may be due to different instrumentation or not fully ideal situation for observation. (In astronomy, different seeing for each night may be an example for this, or telescopes at different sites around the world.)

These zero point variations produce noise in the low frequency domain, which can be reduced with this technique.

To compensate for these effects the *menu entry "Adjust selection"* in the *menu "time string"* has to be selected. Before this, a fit to the data should be done, as this routine uses the residuals to calculate the residual zero points for the different labels of an attribute.

The **adjust zero point for selection dialog** (figure 4.10) has four buttons on top with which the selection of the attribute to be investigated can be chosen.

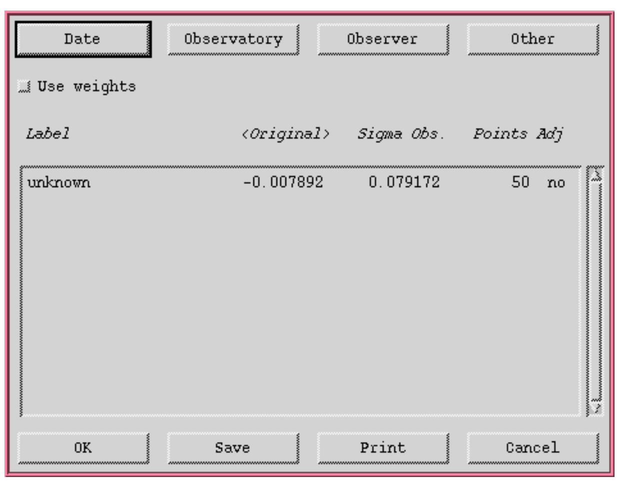


Figure 4.10: The "adjust zero point for selection" dialog

The **use weights** check box indicates whether weighted residuals have been used to calculate the average and sigma. The list box lists all the labels of the selected attribute along with the average, sigma and number of points for this label.

If the last column contains a "yes", this means that some or all of the points have already been adjusted before.

To adjust some labels, they should be selected in the list box and then the **"Ok"** button should be pressed. After each adjustment, a new fit should be calculated to reflect the new situation of the data.

The current list can also be printed by pressing the **"Print"** button or can be saved to file by pressint the **"Save"** button.

Note: Please do not forget to select the adjusted data from this point on for calculations.

4.2.7 Edit label

This **edit label dialog** (figure 4.11) is shown when one of the **"Edit"** buttons in the **time string folder** (section 4.2.1) has been pressed. It offers the possibility to change the color and weight for each selected label in the attribute.

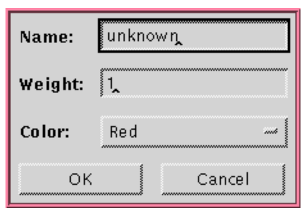
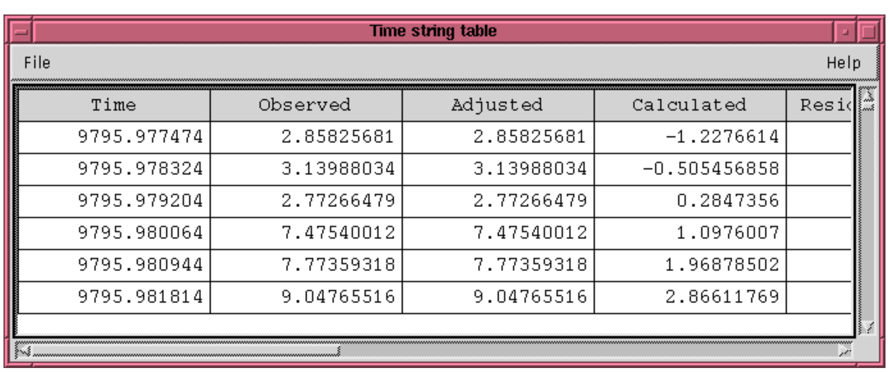


Figure 4.11: The "edit label" dialog

4.2.8 Time string table

When the **"Display table"** button in the **time string folder** (section 4.2.1) is pressed, a **window** (figure 4.12) is shown. This displays the selected time string in every detail. A printout of this table is possible by selecting the *menu entry "Print"* in the *menu "File"* of that window. The attribute labels for a certain point can be edited by clicking with the right mouse button in that line. (See **Change attribute label** (figure 4.13))



Time	Observed	Adjusted	Calculated	Resi
9795.977474	2.85825681	2.85825681	-1.2276614	
9795.978324	3.13988034	3.13988034	-0.505456858	
9795.979204	2.77266479	2.77266479	0.2847356	
9795.980064	7.47540012	7.47540012	1.0976007	
9795.980944	7.77359318	7.77359318	1.96878502	
9795.981814	9.04765516	9.04765516	2.86611769	

Figure 4.12: The "time string data" window

Note: With the *control key on the keyboard* pressed at the same time as the right mouse button, the data point is immediately deleted without further questioning.

4.2.8.1 Change attribute label for a point

This allows to change all the labels of a certain point of the time string by clicking with the right mouse button on the data point in the Graph of Table view. This opens up the **Change attribute label for a point** (figure 4.13) dialog, in which the labels for the selected point can be changed.

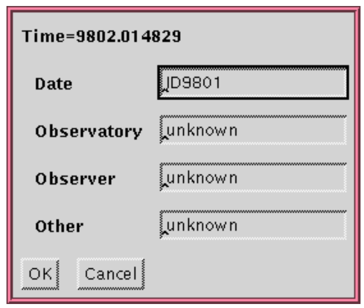


Figure 4.13: The "change attribute label for a point" dialog

Note: After renaming a point, it is not necessarily any longer in the currently selected time string, as the newly given label may not be selected.

4.2.9 Time string graph

When the **"Display graph"** button in the **time string folder** (section 4.2.1) is pressed, a **window** (figure 4.14) is shown. This displays the selected time string as colored dots together with a curve representing the current fit.

There are 4 options in the *menu "Data"*, which allow to select the kind of data to investigate:

- Original: displays the original data together with the current fit
- Adjusted: displays the adjusted data together with the current fit
- Residuals(obs): displays the residuals to the observed values.
- Residuals(adj): displays the residuals to the adjusted values.

Note: The current fit is *only* plotted, when the resolution of the screen is high enough to display the fit without any sampling problems.

A printout of this graph is possible by selecting the *menu entry "Print"* in the *menu "File"* of that window.

Similar to the **Time string table window** (section 4.2.8) , points can be renamed or deleted.

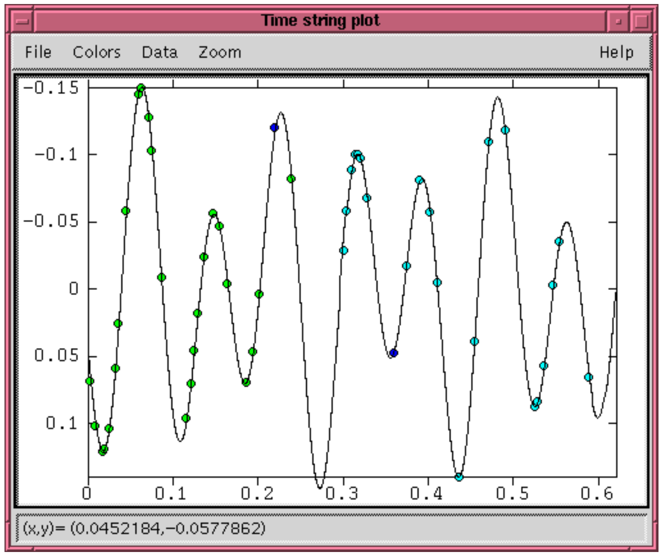


Figure 4.14: The "time string graph" window

Note: Beware: The cursor has to be close to the point itself and no other point may be close. If these conditions are not fulfilled, then no point is deleted. A beep signifies that a point has been deleted.

The colors are defined by the color of the labels of the attribute that is selected in the *menu "Color"*.

The graph also allows zooming into the data. Selecting an area with the left mouse button zooms into that area. Changing the displayed area can be achieved by the *menu entry "Select view port"* in the *menu "Zoom"*. See **Change view port** (section 4.2.9.1) for exact explanations. Finally the original view can be restored by selecting *menu entry "Display all"* in the *menu "Zoom"*.

The status bar writes the current position of the mouse, while it is over the display.

4.2.9.1 Change view port

To invoke the **Change view port dialog** (figure 4.15) , the *menu entry "Select view port"* in the *menu "Zoom"* has to be selected in the **Time string graph** (section 4.2.9) . There the current values of the view port are listed and can be changed.

4.2.10 Delete default label

To change the default values of attribute and label for deleted points, the *menu entry "Delete default label"* in the *menu "time string"* of the main window has to be selected.

This opens up the **delete default label dialog** (figure 4.16) .

This is only relevant in the time string **table** (section 4.2.8) and **graph** (section

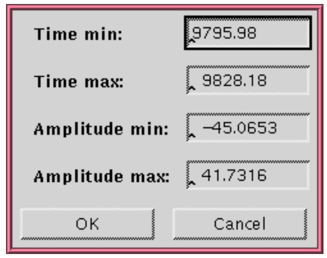


Figure 4.15: The "change view port" dialog

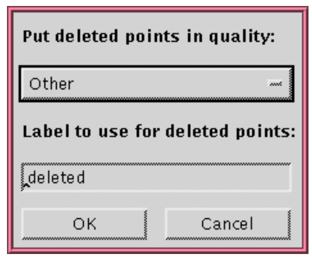


Figure 4.16: The "delete default label" dialog

4.2.9) .

4.3 Fit

4.3.1 Fit folder

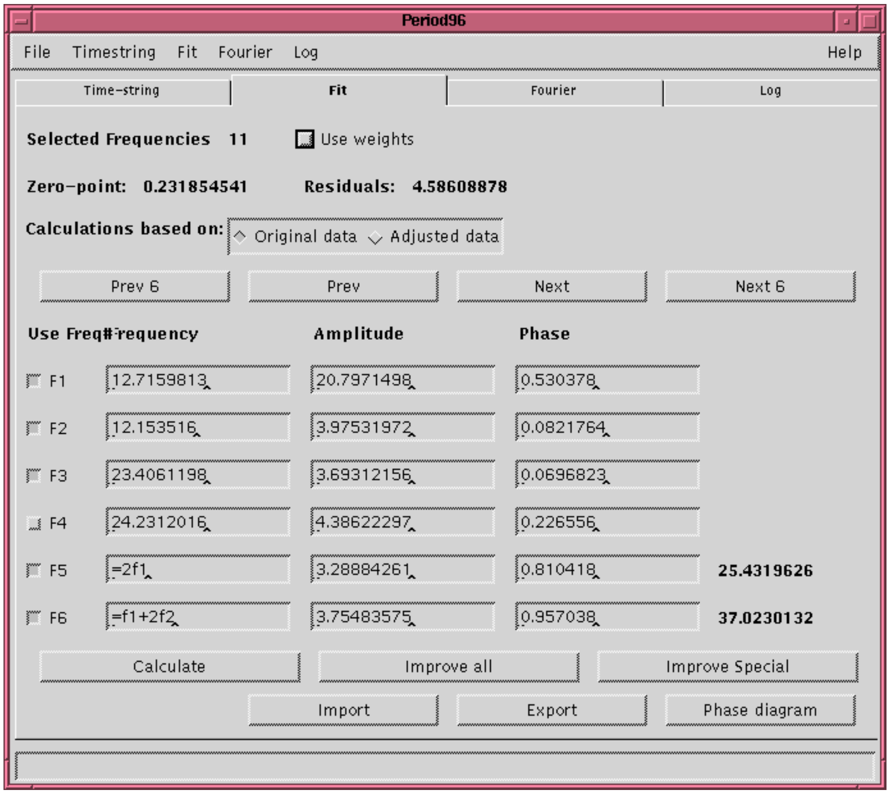


Figure 4.17: The frequency folder

This folder shows almost all the information regarding the current fit. (In some rare circumstances the **log folder** (section 4.5) may provide more detailed information.)

Active frequencies: Gives the total number of active frequencies. These are the frequencies for which in the frequency table, the check box is selected near the frequency number.

Use weights means: use the time string in a weighted form for the least square fit calculation, if it has been selected.

Zero point: Shows the calculated zero point for the last calculated fit.

Residuals: Shows the residuals for the last calculated fit.

Calculations based on: dialog item indicates which data set will be used for the next calculation. Either the **original** or the **adjusted** data.

With the four buttons: **Prev X**, **Prev**, **Next**, **Next X** scrolling in the frequency list is possible. (Prev is short for previous.) (X depends on the size of the screen, but can also be specified with a command line switch of -r<rows> when invoking the program.)

The next view lines give information on some of the frequencies themselves.

The first column gives the **number of the frequency** with the possibility to activate or deactivate it by selecting the check box.

The next column gives the value of the **frequency** itself. In case of a **harmonic** or **frequency combination** the contents will be preceded by `‘‘=’’` and may be of one of the following formats:

frequency combination:

- =fx+fy
- =nfx+mfy or =n*fx+m*fy

harmonic:

- =hfx or =h*fx

x,y may be values from 1 to 255, but not be the number of the frequency itself or a reference to another frequency which is itself a combination. If one of the composing frequencies is not active, the combination is not active either! h may be an integer greater than 1, while m,n can be any integer number.

When entering or editing a frequency value, another feature may make life easy: if an arbitrary number of “+” and “-” are trailing the number, then the value of the **alias gap value** (section 4.3.2) is added to or subtracted from the value, as often as “+” or “-” are given.

The following two columns give the value of the **amplitude** and **phase**.

The last column, which is by default not visible, tells the current numerical value of a composite frequency or harmonic.

The next 3 buttons start a calculation:

- **“Calculate”** button takes the current settings and improves the amplitudes and phases of all active frequencies.
- **“Improve all”** button takes the current settings and improves not only amplitudes and phases, but also the frequencies.
- **“Improve Special”** button gives full power to the user for calculations, as it allows to decide for every active frequency, amplitude or phase whether it should be a fixed or free parameter. This option also allows the calculation of **amplitude and/or phase variations** (section 4.3.4) .

Import reads in a set of predefined frequencies.

Export writes out the whole table of frequencies.

Phase plot allows to display the selected time string as a phase plot to a selectable frequency.

4.3.2 Alias gap

As already mentioned in the **Fit folder** (section 4.3.1) , a frequency may be shifted up or down by some arbitrary value by placing "+" or "-", after the frequency value itself. This value is closely connected to the spectral window function of the currently selected time string. For astronomical reasons, the default is set to 1/365. This value is a good estimate for a time string with large gaps (of approximately a year) between densely packed data.

The **alias gap dialog** (figure 4.18) , which can be reached from the *menu "Fit"* by selecting the *menu entry "Alias gap"*, allows to change this value.

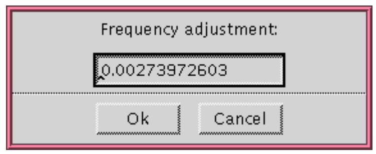


Figure 4.18: The "alias gap" dialog

4.3.3 Improve Special

As already mentioned in the description of the **Fit folder** (section 4.3.1) , **Improve special** gives full control over the calculation to make.

Note: This option should only be used with great care and only after a stable solution has already been reached with the **"Calculate"** button or **"Improve"** button.

Note: Improve automatically does a calculate before trying to improve the frequencies as well! This safeguard has not been implemented for **Improve Special**, as this might effect the desired result in unwanted ways.

The **improve special dialog** (figure 4.19) basically contains 3 list boxes. These list the frequency, amplitude, and phase for every active frequency. For ease of recognition, in front of each value the number of the frequency itself is written. As for the frequency list, frequencies that are combinations or harmonics are not listed.

As an example, a list of predefined frequencies (f1, f2 and f3) is already known, and should stay fixed. But other additional frequencies (f4 to f10) should be improved. Then in the list box with the frequencies all frequencies but the first three should be selected, as well as all the amplitudes and phases.

The three buttons in the bottom allow different calculation modes.

- **"Calculate"** button gives the requested calculation
- **"Calculate amplitude/phase variations"** button opens up another dialog, giving access to an even more specialised calculation mode. See **Amplitude/phase variations** (section 4.3.4) for details.
- **"Cancel"** button stops the calculation.

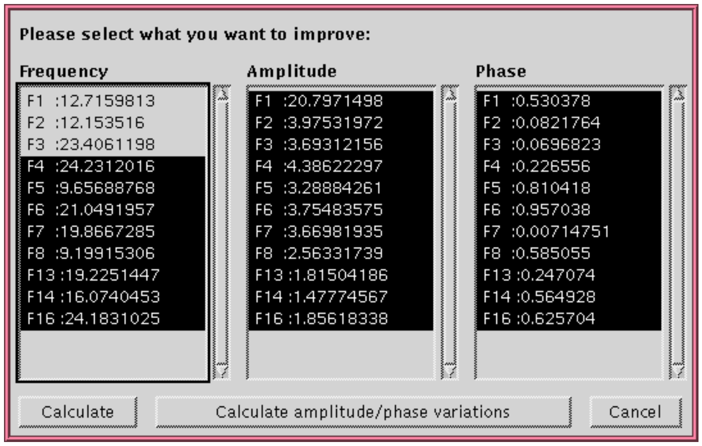


Figure 4.19: The "improve special" dialog

Note: Interpretation of the log output of the **Fit** module:
It will output a before/after scenario with all the active Frequencies listed. Values that have leading and trailing asterisk are free parameters to the fit. The others are fixed.

Note: And a final note: the **zero point** is *always* a free parameter!

4.3.4 Calculate amplitude/phase variations

The last and most sophisticated calculation mode provided by the **fit module** is the **Amplitude/Phase variation mode**. This allows to analyze data where amplitudes and/or phases have different values, for different subsets of the currently selected time string.

An example for this is the observation of daily high and low temperature averages. Or a star that changes intrinsically its amplitude for some frequency. Also measuring an object in two filters generally gives different amplitudes and phases for each filter.

Why is this calculation mode necessary? Fitting different subsets is possible and should give the same results.

This is not fully true, as precision of the final result gets lost. Not only because of the limited number of points, but also because the frequency for each of these subsets will yield a slightly different result when using **improve** for calculation. Thus the results are not fully comparable, especially when large datasets with huge gaps (say maybe 10 years) are used.

But will **calculate** or **improve special** not do the magic to some extent? True again, but again a certain frequency has to be assumed from the start for all subsets, which will still not represent the best fit.

But a blind eye shot with this new tool will not give necessarily the wanted results either. Because, when the degrees of freedom are increased for the calculations (and that is what amplitude/phase variation does!), the numerical stability may be compromised.

So this tool should only be used with great caution and the number of frequencies, which are tested for amplitude and/or phase variations, should be kept to a minimum. Other techniques should be used first to find such variations and only *then* this tool should be used.

The other techniques are: calculating values for different subsets and the more optical approach of using the **phase plot** (section 4.3.12) feature of the **fit module**.

After the **"Calculate amplitude/phase variations"** button has been pressed in the **Improve special dialog** (section 4.3.3) , the **amplitude/phase variation dialog** (figure 4.20) shows up.

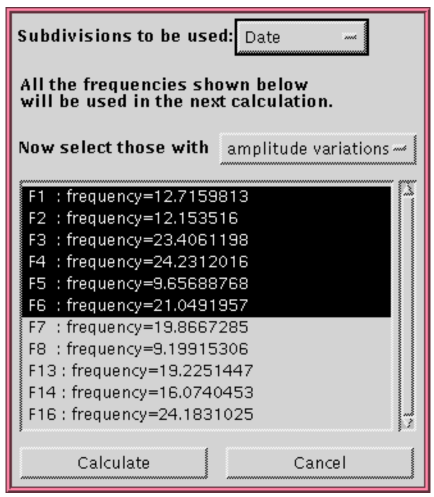


Figure 4.20: The "amplitude/phase variation" dialog

First an **attribute** has to be chosen, for which its selected labels define subsets of the time string.

Then the **calculation mode** has to be selected. Possibilities are:

- amplitude variation
- phase variation
- amplitude and phase variation

And finally the **frequencies** for which amplitude/phase variation should be done, have to be selected. The ones not selected are assumed to have the same amplitude and phase for all points.

The **"Calculate"** button starts the calculation. As the **fit folder** (section 4.3.1) does not offer the possibility to show the complex results in its window, a new dialog shows up, which tabulates the result.

The **fit folder** (section 4.3.1) will only reflect changes to the values, for which separate amplitude and phase variation has not been done.

The residuals are calculated correctly and individual residuals for the subsets can be examined with the **Adjust selection** (section 4.2.6) tool in the **Time**

string module (section 4.2.1) .

4.3.5 Calculate message

When calculating a fit the main window will change its appearance to the following:

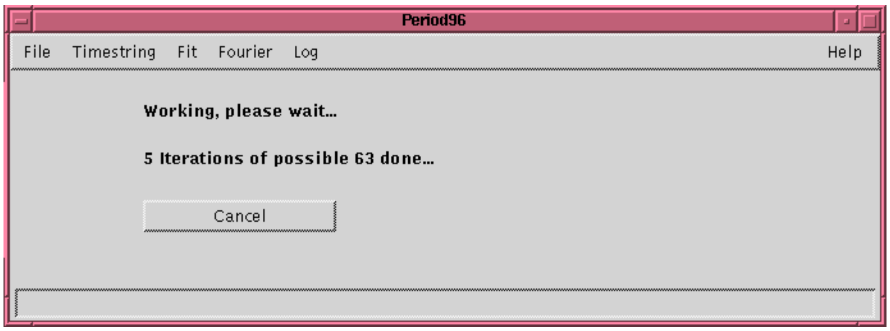


Figure 4.21: The "calculate status" window

It informs about the current state of calculations, where the first number is the number of iterations already done. The second number tells at what number of iterations the program will stop iterating and ask for advice.

With the **"Cancel"** button the calculation can be stopped prematurely. In this case, the result may not be a stable solution.

4.3.6 Predict signal

With the *menu entry "Predict"* in the *menu "Fit"* it is possible to predict an amplitude at a certain time from the current fit. The **predict amplitude dialog** (figure 4.22) only allows to enter a **time** and the **"Calculate"** button will update the display accordingly.

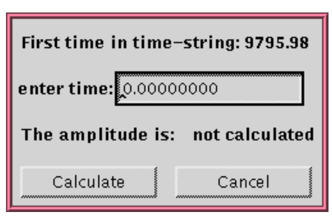


Figure 4.22: The "predict amplitude" dialog

4.3.7 Create artificial data

With the **create artificial data dialog** (figure 4.23) , which can be activated by selecting the *menu entry "Create artificial data"* from the *menu "Fit"*, it is possible to create an equally spaced artificial time string.

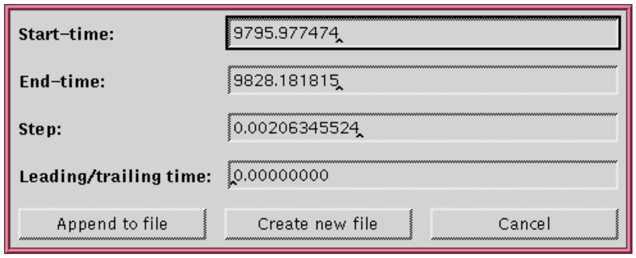


Figure 4.23: The "create artificial data" dialog

To do so, **Period98** has to know about the **start** and **end time** for the selected time span and as well the **steps** in between defaults for this values are: first and last time of the currently selected time string and for the step 1/(20*Fmax) to give a good sampling for the highest frequency as well.

Leading/trailing allows to extend the time span defined by start and end in both directions further by a common value.

After pressing the **"Append to file"** button or the **"Create new file"** button a file needs to be selected. For *append* the data will be appended to the file, and with *create* a new file will be created, and the old file destroyed.

To create artificial data with times from the currently selected time string, the "wished" frequencies should be entered in the **Fit folder** (section 4.3.1) and then the *menu entry "Recalculate residuals"* in the *menu "Fit"* should be used to **recalculate the residuals** (section 4.3.8) . Then the calculated values can be exported with **Time string export** (section 4.2.3) .

4.3.8 Recalculate residuals

With the *menu entry "Recalculate residuals"* in the *menu "Fit"*, it is possible to update the residuals using the values of the current fit. In addition, the zero point will be asked in the **zero point dialog** (figure 4.24) before the calculations are done.

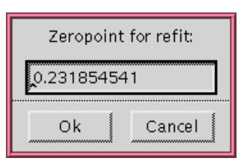


Figure 4.24: The "zero point" dialog

4.3.9 Epochs

The time of maximum light closest to a certain time (epoch) according to the current fit can be calculated by selecting the *menu entry "Epoch"* in the *menu "Fit"*.

Then the **epoch dialog** (figure 4.25) will show up, which basically lists the table of frequencies along with the epoch. **Time of epoch** gives the time, for which the epochs should be calculated. And **Data is in intensity** allows for correct interpretation of maximum light. By default magnitudes are assumed!

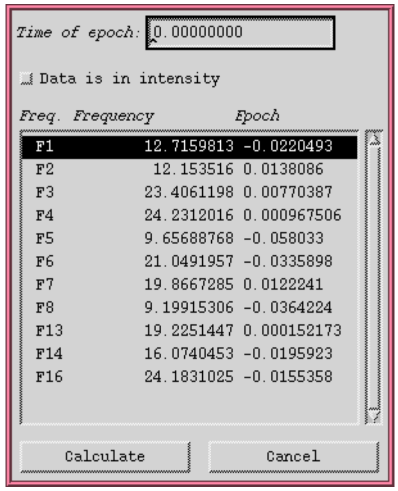


Figure 4.25: The "epoch" dialog

The **"Calculate"** button will update these results.

4.3.10 Import frequencies

To import a table of frequencies, all that is needed to do is to press the **"Import"** button in the **Fit folder** (section 4.3.1) . Then a file selector dialog will show up and a file to read in may be selected.

The table of frequencies will be erased and the information will be filled in.

The file format is the following for *each* line:

- Frequency identifier: in the format: F<num> or f<num>
- if a bracket is the next character, then the frequency is assumed to be inactive
- frequency
- amplitude (optional)
- phase (optional)
- additional data ignored

Lines starting with "/", ";", "#", "%" are assumed to be comment lines.

4.3.11 Export frequencies

To export the table of frequencies, all that is needed to do is to press the **"Export"** button in the **Fit folder** (section 4.3.1) . Then a file selector dialog will show up and a filename to save may be selected.

For the format of the output file please see **Import frequencies** (section 4.3.10) .

4.3.12 Phase plot

As a last tool, the **Fit module** offers the possibility of phase plotting the selected time string. This tool has been in use for a long time and has had its prime time in the early days of asteroseismology. Nowadays this tool is scarcely used, even though it can prove to be a powerful visual diagnostic tool. It allows to view the shape of a light curve not in numbers but visually. And this possibility can help finding a solution to some, otherwise possibly overlooked, properties in the data.

The plot basically uses the the reminder of time of a point multiplied by a certain frequency, which can be edited by the user, as abscissa, and as Y-Axis most frequently residuals (of any kind - Original or Adjusted) to plot a point.

By default, **Period98** tries to find a frequency in the list of frequencies, that has not been activated and chooses the first one found. This frequency is displayed in the top part of the graph. If none is found, then a frequency of 1.0 is chosen.

The point itself is plotted as a filled circles with a color that corresponds to the color of one of its attributes labels. To change the the attribute to use for to select the color, the *menu "Color"* is used. (See **Edit name properties** (section 4.2.7) in the **Time string folder** (section 4.2.1)) for how to change the color for a label.)

With the *menu "Data"* the data to be displayed on the Y-axis can be selected.

For explanation of the **Color, Data and Zoom menus** please see the documentation on **Time string graph** (section 4.2.9) .

Some of the possible uses of this graph are:

- finding systematic changes of amplitudes in different subsets of the time string.
- finding systematic changes of phases in different subsets of the time string.
- detecting "bad" data, which do not follow the average "light curve shape" for whatever reason.
- reveals the "true" "light curve shape", as the light curve does not have to be sinusoidal, but still periodic.

Note: Note: with **harmonic frequencies**, that can be entered in the frequency table, these light shapes may be "approximated" quite accurately and thus be removed from the residuals.

So, how does it work? Bringing up the **Phase plot** (figure 4.26) is as easy as pressing the **"Phase plot"** button in the **Fit folder** (section 4.3.1) .

The *menu "Frequency"* gives all the necessary possibilities that have to do with the graph, like changing the frequency used for calculating the phase of a point, or to activate the **binning feature**, which allows to extract the light shape "corresponding"to this frequency. For closer detail please see **Binning** (section 4.3.12.1) .

The values from which the graph has been created, can be written out in a similar manner as the normal **time string export** (section 4.2.3) . The only difference is that instead of time, phase is written out.

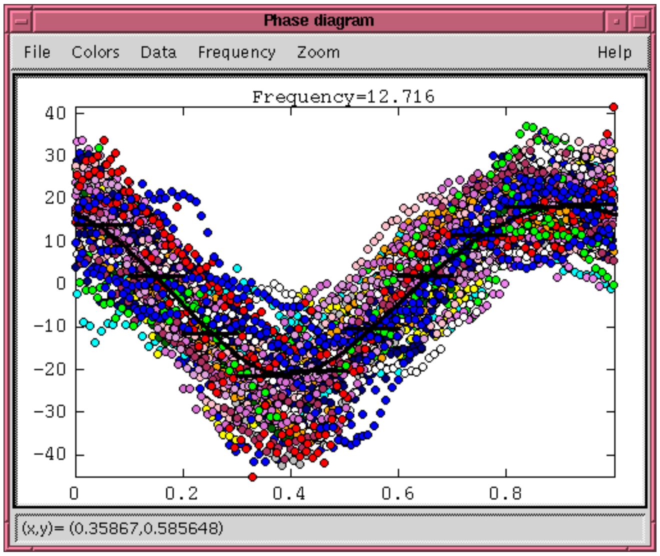


Figure 4.26: The "phase plot" window

4.3.12.1 Binning

As already mentioned, the "Phase plot" also offers the possibility of binning, which is averaging data for discrete phase ranges and displaying these values along with error bars. Additionally, a spline like curve is fitted to the data resulting from this procedure.

The size of the bin box can be changed by selecting the *menu entry "binning spacing"* in the *menu "Frequency"*. Then the **Binning spacing dialog** (figure 4.27) will open up and ask for a new value. This value should be in the range of **0** and **1** exclusively!

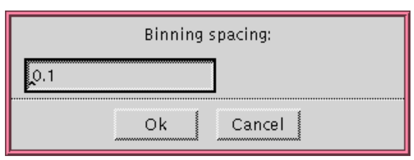


Figure 4.27: The "binning" dialog

The binned values can also be exported to a file by selecting the *menu entry "Export binned"* in the *menu "File"*. This file contains 3 columns: phase, mean amplitude and sigma of mean.

4.3.12.2 Frequency choice

If the frequency used in the graph needs to be changed, then the *menu entry "Change Frequency"* in the *menu "Frequency"* should be selected. This opens up the **frequency choice dialog** (figure 4.28) .

This Dialogs contains a list box, that lists all deactivated frequencies, as **Pe-**

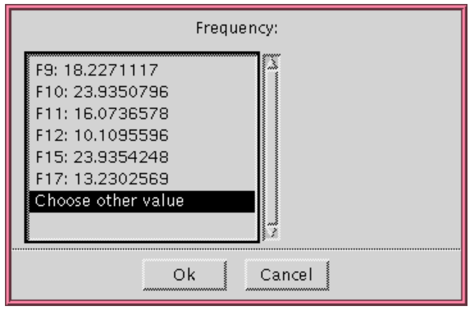


Figure 4.28: The "frequency choice" dialog

riod98 assumes that activated frequencies already have been prewhitened. Selecting one of these and pressing the **"OK"** button selects this frequency and updates the graph and binning accordingly.

If a totally different frequency needs to be selected, then there is also the "Choose different value" in the list box. When this has been selected the **custom frequency dialog** (figure 4.29) will show up, and a new frequency can be entered.

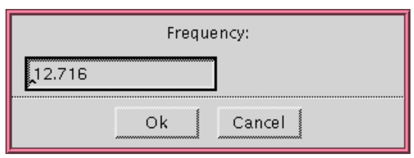


Figure 4.29: The "custom frequency" dialog

4.4 Fourier

4.4.1 Fourier folder

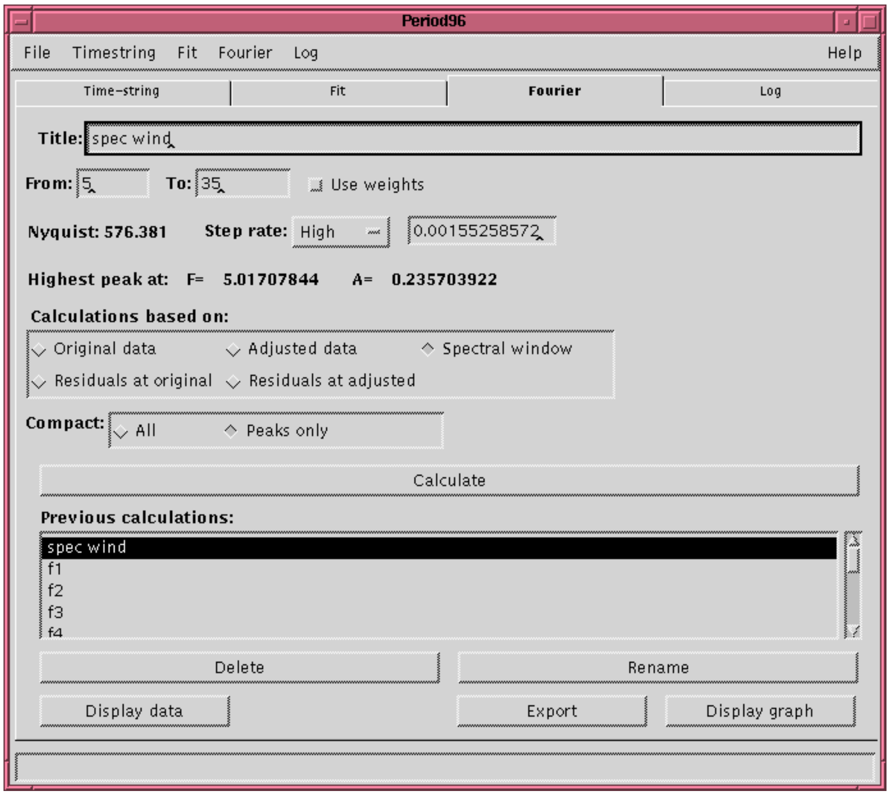


Figure 4.30: The “Fourier” folder

This folder shows all the necessary information that has to do with Fourier transformation.

The basic idea behind this folder is that different Fourier calculations can be kept in memory simultaneously and that the setting for each of these *Fourier sets* can be restored with a click of the mouse.

Because of this possibility there is a need for a **Title** for identification by the user. Then there are **From** and **To**, which define the frequency range, for which the Fourier spectrum should be calculated. As with the **fit module** (section 4.3.1) there is the possibility to use weighted data for the Fourier calculations.

In the next line the Nyquist frequency is displayed. This value should be a good estimate for the upper limiting frequency due to the sampling pattern in the currently selected time string. This frequency value given does *not* depend only on the time base and the number of points in the currently selected time string, but uses a more sophisticated algorithm, estimating the average time gap between neighboring points, ignoring large gaps.

With the choice item **Step rate** it is possible to change the accuracy of the Fourier calculation. This means, that the step at which the frequency range is sampled can be changed. **High, medium and low** are good estimates (High uses most time to calculate). With **Custom** a user defined value can be chosen in the text item next to it. For all the other 3 possibilities the text item can not be edited and will contain the value that would be used in this case.

Next the **highest peak** line gives the highest peak that was found during the calculation with the coresponding frequency and amplitude.

With **Calculations based on** it is possible to select different data types for the calculation. These correspond to the values that can be displayed in the **Time string graph** (section 4.2.9) and **Time string table** (section 4.2.8) . **Spectral window** allows the calculation of the spectral window centered at zero frequency for the currently selected time string.

The **Compact** option allows to limit the - often very massive - output of Fourier, because with **Peaks only** only the local minima and maxima are kept.

The **"Calculate"** button takes all the settings above and calculates a new Fourier spectrum with this. (See **Fourier calculate** (section 4.4.2) for more details.

In the list box below the **"Calculate"** button, all the previous Fourier calculations are listed with their title. Selecting one of these will update all the values above to the values used for that specific calculation.

With the **"Delete"** button the currently selected Fourier calculation can be removed from memory - only the log file entries will remain. The **"Rename"** button allows to change the title for the currently selected Fourier calculation. To do so, the **rename title dialog** (figure 4.31) is opened.

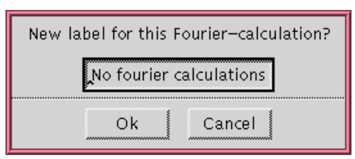


Figure 4.31: The "rename title" dialog

The **"Display data"** button opens up the **Fourier data window** (section 4.4.5) and allows examination of the output of the calculation.

Next the **"Export"** button allows the output to be written to a file. (See **Fourier export** (section 4.4.4) for details.)

Finally the **"Display graph"** button opens up the **Fourier graph window** (section 4.4.6)

4.4.2 Fourier calculate

When starting a Fourier calculation with the **"Calculate"** button in the **Fourier folder** (section 4.4.1) , the main window will change to represent the **current status of calculation** (figure 4.32) . In this case it will give the percentage of the calculations completed. Again the **"Cancel"** button can stop the calculations.

In the case of **observed** or **adjusted** values selected for calculations, the user

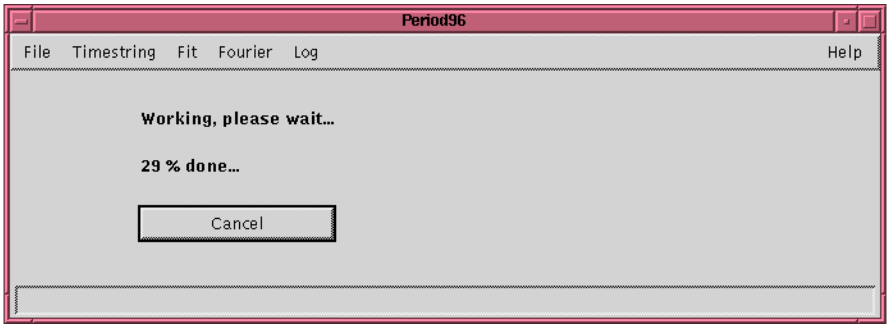


Figure 4.32: The "Fourier calculate" window

will first be asked if the average zero point should be subtracted with the **zero point dialog** (section 4.4.3) .

After the calculation has finished, the **include dialog** (figure 4.33) will show up and ask, if the currently found highest peak should be included in the list of frequencies of the **Fit module** (section 4.3.1) .

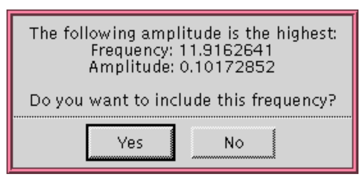


Figure 4.33: The "include" dialog

4.4.3 Zero point

The Fourier transform has the property, that if the mean amplitude of the currently selected time string for calculation is *not Zero* additional features in the low frequency range will show up. This is due to this Zero point shift and the features showing up are comparable to a scaled spectral window centered at frequency 0. This feature may even dominate the whole spectrum.

To overcome this problem **Period98** will ask with the **zero point dialog** (figure 4.34) , if it should subtract a (calculated) zero point, when the calculations are based on **Original** or **Adjusted** data.

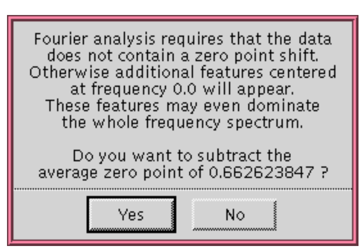
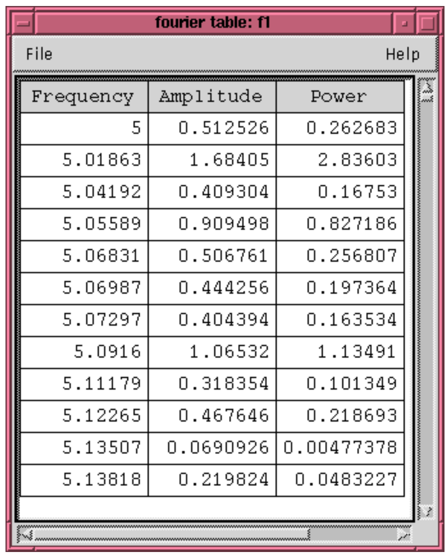


Figure 4.34: The "zero point" dialog

4.4.4 Fourier export

4.4.5 Fourier table

This **window** (figure 4.35) , which shows up, when the **"Display data"** button in the **Fourier folder** (section 4.4.1) has been pressed, shows a table of **frequencies, Fourier amplitudes and Fourier power**, of the currently active Fourier calculation.



fourier table: f1

File Help

Frequency	Amplitude	Power
5	0.512526	0.262683
5.01863	1.68405	2.83603
5.04192	0.409304	0.16753
5.05589	0.909498	0.827186
5.06831	0.506761	0.256807
5.06987	0.444256	0.197364
5.07297	0.404394	0.163534
5.0916	1.06532	1.13491
5.11179	0.318354	0.101349
5.12265	0.467646	0.218693
5.13507	0.0690926	0.00477378
5.13818	0.219824	0.0483227

Figure 4.35: The "Fourier table" window

4.4.6 Fourier graph

The **Fourier graph window** (figure 4.36) will show up, when the **"Display Graph"** button in the **Fourier folder** (section 4.4.1) has been pressed. It will show the graph of the currently active Fourier calculation.

Actually many of the menus are the same as for the **time string graph** (section 4.2.9) .

The only new feature is the *menu "display"*, in which it is possible to change the graph to display *power* instead of *amplitude* with the *menu entry "Use power"*.

4.4.7 Noise

Sadly observations are not perfect and usually contaminated with noise. This noise may come from many sources: Observations, instrumentation, the object itself, modes (frequencies) not yet found in the spectra, etc...

As this noise is thus only pseudo-random there is no way to eliminate it during data reduction. Thus all the noise produces some unpredictable pattern in the Fourier spectrum. So it is possible, that some peaks in the Fourier spectrum are found that are not present in the object observed.

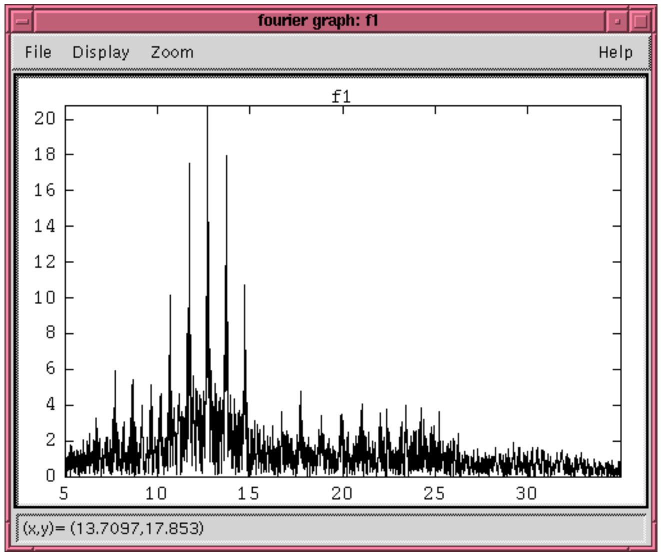


Figure 4.36: The "Fourier graph" window

But how can noise be separated from a real signal? There is never a guarantee for a sure identification, but observational (Breger et al., 1993 (A&A 271,482)) and numerical simulations (Kuschnig et al.,1997 (A&A 328,544)) have shown, that the *ratio* between *signal* and *noise* in amplitude should at least be 4.0 to give good confidence.

So **signal** is defined as either the amplitude in the **Fourier spectrum** or the amplitude of the **least square fit solution** for a certain peak, and **noise** is defined as the average amplitude in a close frequency range to the peak unde consideration after subtracting the frequency with the **fit module** (section 4.3.1) and using the resulting residuals for the calculation of noise. The **Fourier module** (section 4.4.1) offers two options to calculate noise. These are: **Noise at frequency** (section 4.4.7.1) and **Noise spectrum** (section 4.4.7.2) , which both can be reached from the *menu "Fourier"*.

4.4.7.1 Noise at frequency

When the *menu entry "Noise at frequency"* in the *menu "Fourier"* has been selected, the **noise at frequency dialog** (figure 4.4.7.1) will show up.

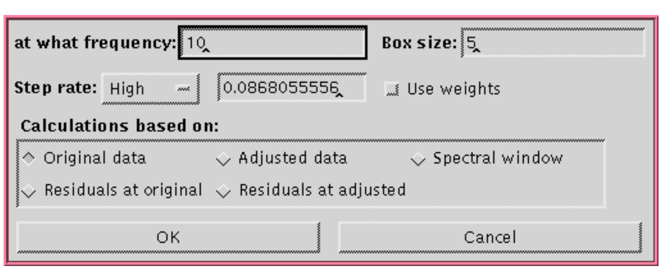


Figure 4.37: The "noise at frequency" dialog

Most of the contents of this dialog are similar to that of the **Fourier folder** (section 4.4.1) .

The only difference is that the frequency at which the noise calculations should be centered can be entered as well as the extent of the range.

After the **"OK"** button has been pressed and the calculation has finished a window will pop up and show the result.

4.4.7.2 Noise spectrum

The noiselevel is not necessarily constant in the whole frequency spectrum. The **Fourier module** also supports the possibility to calculate a **noise spectrum**.

This is basically the same procedure as for **noise at frequency** (section 4.4.7.1) , but the calculation is repeated at different parts of the frequency range.

When the *menu entry "Noise spectrum"* in the *menu "Fourier"* has been selected, the **noise spectrum dialog** (figure 4.38) will show up.

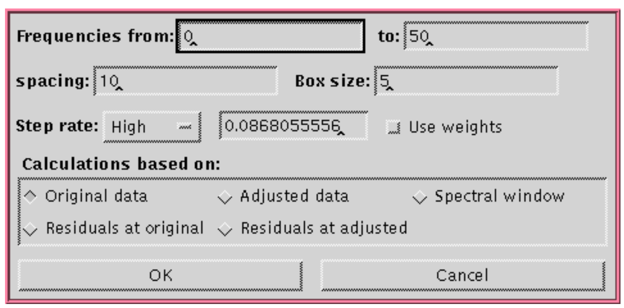


Figure 4.38: The "noise spectrum" dialog

The dialog is very similar to that of **noise at frequency** (section 4.4.7.1) . The main difference is that the frequency range **from** and **to** has to be entered as well as the spacing between consecutive noise values centered at frequencies of interest. After the **"OK"** button has been pressed and the calculation has finished, a window will pop up and show the results.

4.5 Log

This folder contains only a big text dialog, which allows the user to enter some comments of his own, as well as **Period98** itself to put down a written history of what changes have been made to the data and what actions have been taken so far along with the actual time and date.

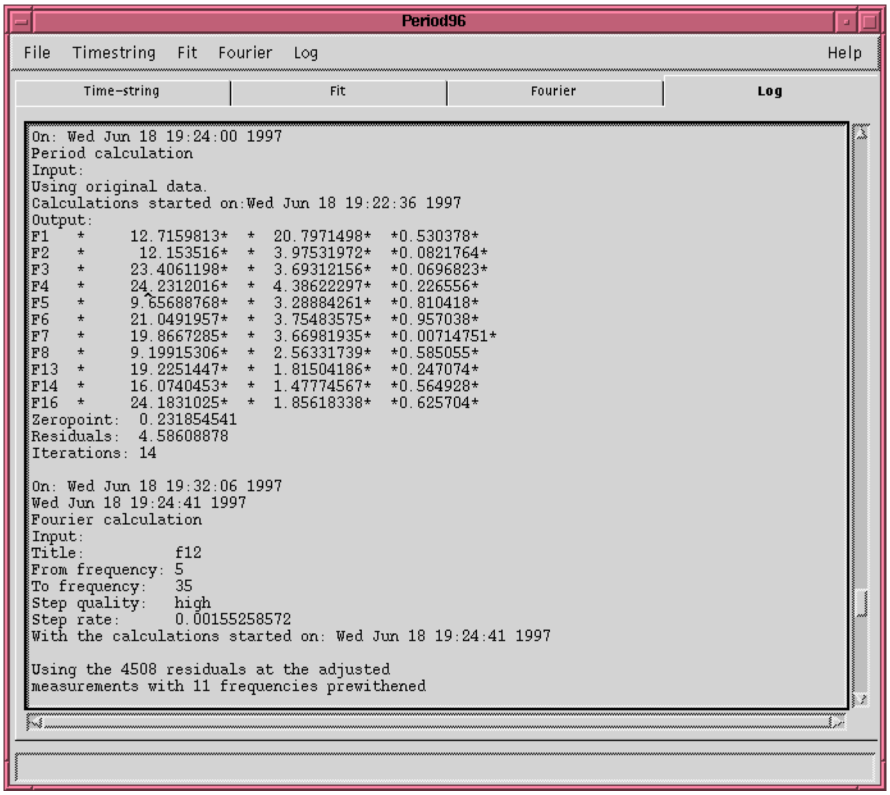


Figure 4.39: The “log” folder

Saving the log file is possible by selecting the *menu entry “Save log”* in the *menu “Log”*.

Printing the log file is also possible selecting the *menu entry “Print log”* in the *menu “Log”*.

Note: Editing/erasing the log is possible in the usual manner.

Note: On Windows95 there is a limitation of the size of text in a text dialog. **Period98** will automatically truncate at the start as it approaches this limit and write a short header in this case...

A. Problems with Period98

Here are some of the problems yet to be resolved:

- Improve Special and composite with one fixed frequency possible?
  If so, then equally spacing is possible in FAQ
- Data tables may not show the last line and redraw problems...

If some problems with **Period98** are found, then please do not hesitate to contact the **Period98** homepage (http://dsn.astro.univie.ac.at/period98) and submit a bug-report from there. Alternatively mail a bug-report to period98@dsn.astro.univie.ac.at.

B. Frequently asked questions

B.1 How can I export residuals?

Please read on the subject of **exporting the Timestring** (section 4.2.3) . There you can select what parts of the timestring you can export. And this naturally includes the residuals as well.

B.2 How can I get other files listed in the file selecter with Unix?

Basically **Period98** assumes a certain extension of file belongs to a certain data type. This is reflected in the file selector.

The pattern used at the begining is not displayed, but the **File/Filter** text input is empty.

Just enter the new file pattern in there and press return and the window will be updated.