

CEPHEIDS QT SOFTWARE

1. Introduction

CepheidsQt is a user-friendly software created for analysis of Cepheids and determination of their subclasses. Software design allow to read and write data directly from Pi of the Sky database or binary files. It is an effective tool for determination of Fourier coefficients and can also be used to calculate probability that a Cepheid belongs to one of the following classes: population I, overtone or population II.

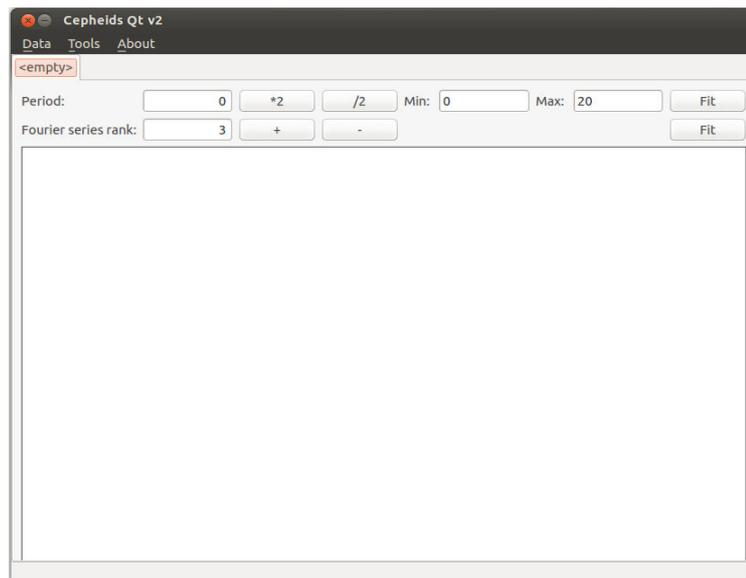


Figure 1: CepheidsQT Interface

2. Options

The overall appearance of the toolbar is shown at figure 2:

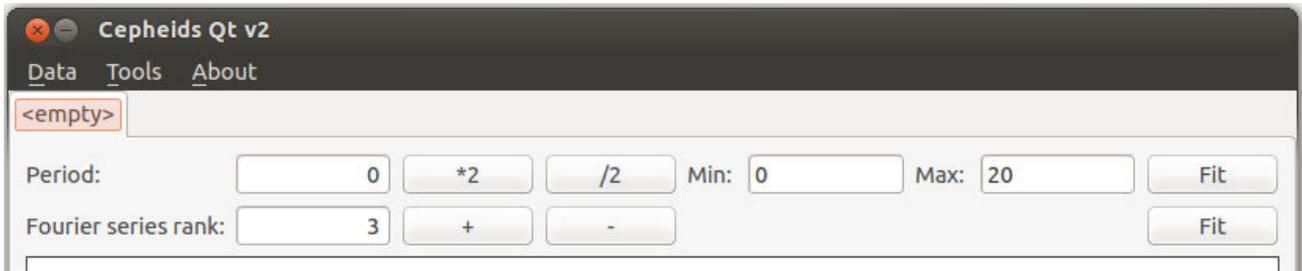


Figure 2: CepheidsQT toolbar

After reading the data the light curve is drawn. User can manipulate with the light curve using following functions:

- Finding a period – if period is known user can write it down into box. By clicking 'Fit' button program will determine period of pulsation from selected range (user should define values in fields 'Min' and 'Max') using method of string length. Also there are two additional button for multiplying/decreasing value of period by two. This option works only when using Pi of the Sky databases.



Figure 3: User can write down the period or program can determine the period between selected values of minimum and maximum range. Two additional buttons allow for multiplying/decreasing value of period by two

- Fitting Fourier series to light curve – after defining the order of the fit the light curves are fitted with:

$$V_r(t) = A_0 + \sum_{k=1}^N A_k \sin(2\pi kf(t-t_0) + \varphi_k)$$

where $f = 1/P$, N is the order of fit, f is the frequency and P is the pulsation period. Next the Fourier phases $\varphi_{k1} = \varphi_k - k\varphi_1$ and the amplitudes ratios $R_{k1} = A_k/A_1$ are calculated. Also the parameter $M - m$ (M is the phase of maximum brightness and m the phase of minimum brightness) is computed, which measures the light curve asymmetry.



Figure 4: After defining the order of the fit Fourier series are fit

3. Menu

The overall appearance of the menu is visible at figure 5:



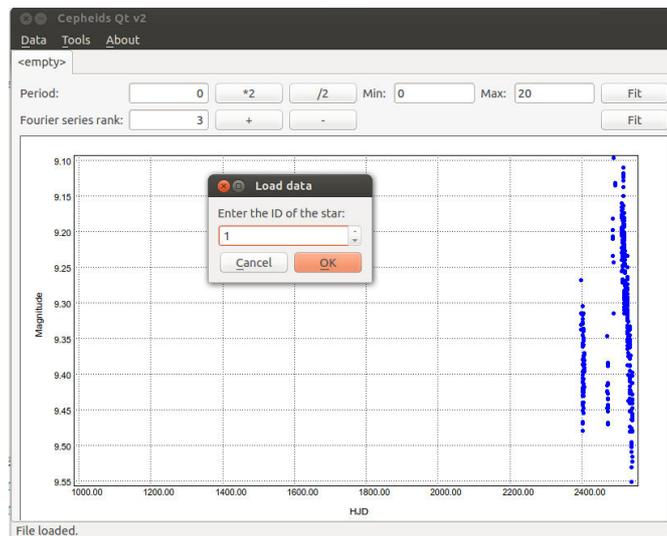
Figure 5: CepheidsQT menu consists of three options: Data, Tools and About

2.1 Data:

There are several options for handling data:

- New tab – opening new tab. It is useful if user want to compare several star light curves.
- Close tab – closing selected tab.
- Load from file – opening binary file with dataset. In file there should be two columns, the first one with time of observation and the second one with brightness observed in each part of time. The file should have an extension 'txt' or 'dat'. Do not use data files, which are not binary files or have format other than specified above.

As program can open several stars program demands to write an id of the star from Pi of the



Sky database or unique number to each star.

Figure 6: In case of reading data from file, program will ask for the ID of the star

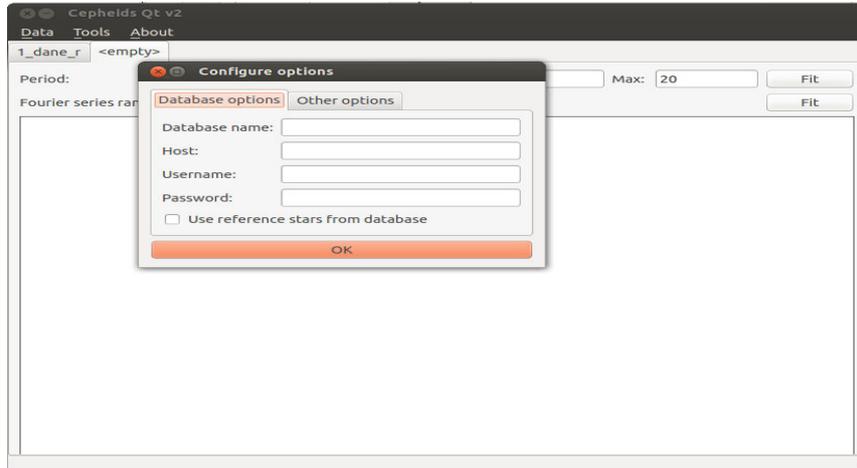
- Load from database – load data directly from Pi of the Sky databases. This option works only on Pi of the Sky servers.
- Convert data from Pi – convert data from file generated after Pi of the Sky procedure of photometry corrections (approximate color calibration algorithm) to format readable by CepheidsQT. Use a file with extension 'lc'.
- Convert data from ASAS – convert data from ASAS database to format readable by CepheidsQT. Load data from file with an extension 'txt' or 'dat'.
- Exit – close the program.

2.2 Tools:

There are several options for configuration and writing results:

- Configure

- Database options – allows to change database, which is used to read stars from Pi of the Sky database and write results. This option works only when using Pi of the Sky databases. User should type name of the database, host, username and password of the database. If reference



stars for neural network should be taken from database check this option.

Figure 7: In case of reading data from another database user should fill configuration information

- Other options – This option works only when using Pi of the Sky databases.
 - Use data after Deep Purple – program can reject the measurements affected by detector imperfections or observations conditions when reading from Pi of the Sky databases. Measurements that are infected by hot pixels, bright background caused by open shutter or moon halo, or by planet or planetoid passage, can be excluded from light curve.
 - Skip measurements far from the camera center – program can reject the measurements that are placed near the border of the frame.

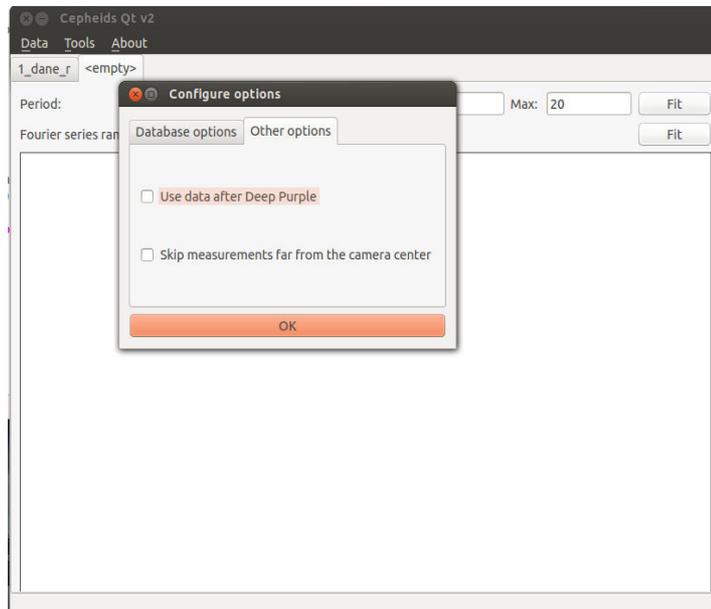


Figure 8: In case of reading data from Pi of the Sky database user can select only data with high measurements precision

- Save Fourier data to file – save the Fourier parameters to the file.
- Save Fourier data to database – save Fourier parameters to the Pi of the Sky database. This option works only on Pi of the Sky servers.
- Draw graphs – save selected graph as portable network graphics ('png'). User can determine what kind of graph want to save:
 - Phased light curve – light curve of the star phased with given period.
 - Fourier parameters – selected Fourier parameter plotted against logarithm of period (also reference stars are plotted).

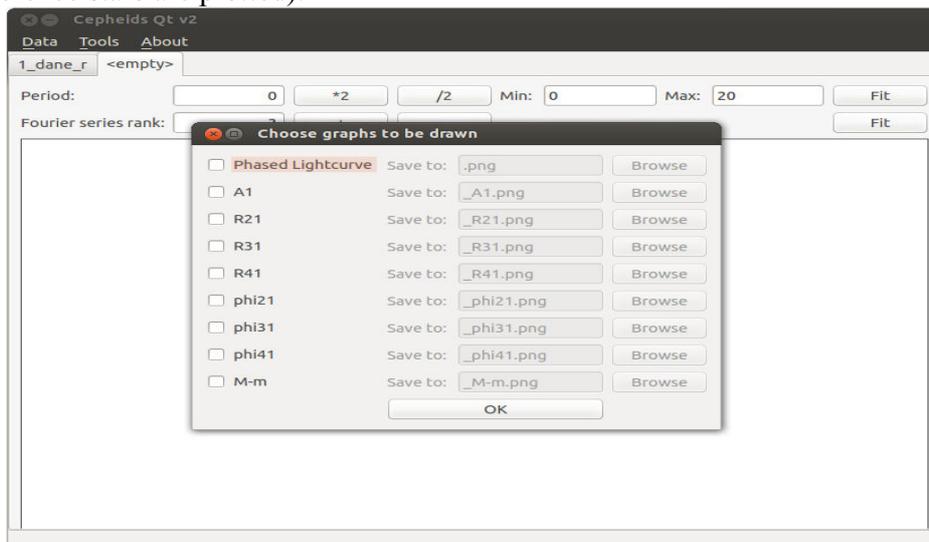


Figure 9: Saving graphs to the file

- Calculate probabilities – The distinction between different subclasses of Cepheids is usually based on the shape of the light curve. Fourier decomposition determined from the light curve allows for almost unambiguous classification due to clear separation of Fourier parameters against period on plots between different classes of Cepheids. Program uses a neural network to calculate probability that a star belongs to one of the subclass of Cepheid depending on Fourier parameters for reference Cepheids. Due to differences in quality of separation among different classes, it is crucial for classification purposes to define which parameters are important. Network in the program is trained with default sample (if another was not selected) defining R21 and phi21 parameters as the most important input parameters. As for R31 and phi31 diagrams the separation is not so clear, these parameters do not play an important role and the neural network has not been trained on higher ratios. As a reference stars we used Cepheids for which Pi of the Sky performed observations with sufficiently high quality. Default sample consists of 178 I population Cepheids, 18 Cepheids pulsating in the overtone overtone, and 42 II population Cepheids.

2.3 About:

Information about program.