ATARRI User's Manual

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1 Introduction

In this document we will explain the layout and basic functionality of the GUI: A TESS Archive RR Lyrae Classifier (ATARRI[1,2]). A description of a scientific research application for the software is in a separate Guidebook[3].

In Figure 1 we show a screenshot of the GUI with the data for an RR Lyrae variable from *TESS* visible. This interface has a wealth of information presented at one time, the ability to modify the selected data, and a way to record information about the object.

In Section 2 we will describe the layout of the information presented in the GUI, Section 3 will discuss the functionality available to the user, and Section 4 will provide a typical workflow.

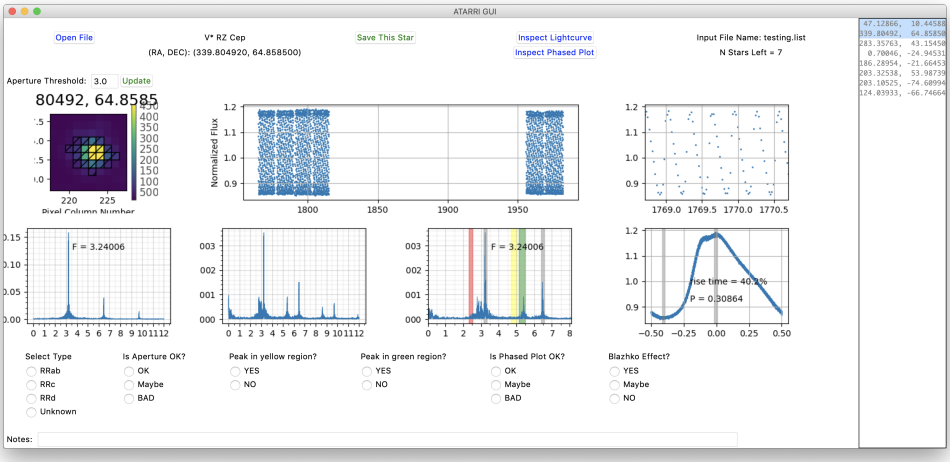

Figure 1: A screenshot of the GUI used to visualize and analyze TESS data of RR Lyrae variables.

2 Layout

Presenting relevant information to a user in an intuitive way is the most important aspect of any GUI. In the main ATARRI window is multiple plots necessary to categorize and describe the properties of an RR Lyrae variable star. In Figure 2 is an annotated view of the GUI shown in Figure 1. Each area of the GUI is numbered, and we provide a brief description of the information contained in each below.

1. "Open File" button (for selecting an input list of stars)
2. Current object information (common name and position on the sky)
3. "Save This Star" button (for saving the information selected in area 14 and calculated properties of the lightcurve done in the background)
4. Buttons for closer inspection of the lightcurve (above) and phased plot (below)
5. Input file information (name above and stars left to go through below)

[1] https://pypi.org/project/ATARRI/
[2] https://github.com/kennethcarrell/ATARRI
[3] https://github.com/kennethcarrell/ATARRI/blob/main/doc/Guidebook.pdf

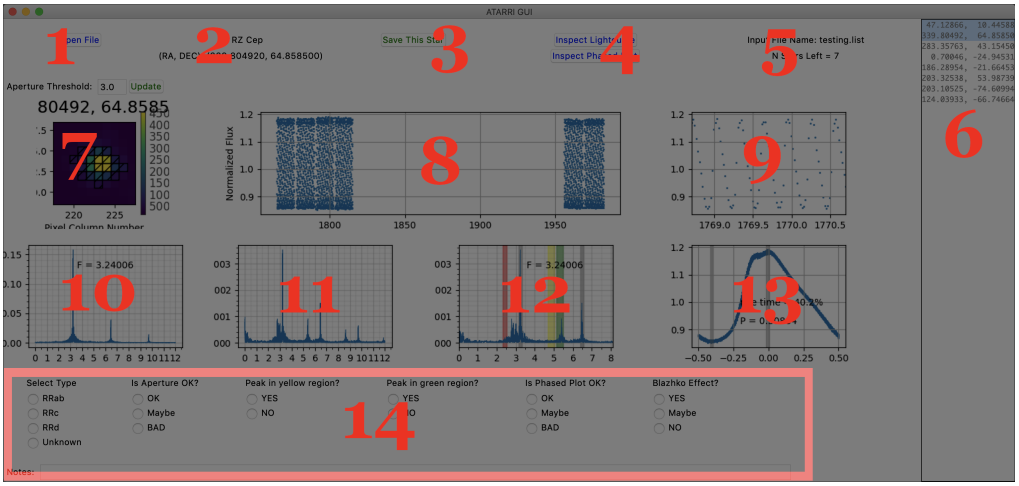

Figure 2: An annotated view of the GUI.

6. List of objects input from file with previously saved and current objects highlighted
7. Cutout of the raw *TESS* full frame image of current object
8. Lightcurve of current object
9. Zoomed in region of lightcurve for easier view of individual cycles
10. Lomb-Scargle analysis of the lightcurve
11. Pre-whitened Lomb-Scargle analysis of the lightcurve
12. Same pre-whitened plot as 11 with interesting regions highlighted in color
13. Phased plot using the period determined from Lomb-Scargle analysis
14. Region for selection of properties

More information about the reason for including the plots chosen, as well as how to use what is presented to make selections in the bottom region are included in the Guidebook.

3 Functionality

3.1 Input

The functionality of the entire GUI begins with the "Open File" button in the upper left portion of the window. There are a few requirements for the input file. First, it MUST be in a normal text format (fits tables are not supported currently). Second, the file MUST NOT contain any header line(s). Lastly, the first two columns in the file MUST be right ascension (RA) and declination (dec) for the object(s). Columns can be separated by any normal separation character (space, tab, or comma). There can also be more than two columns in the input file. Subsequent columns will be ignored, but the first two must contain the position of the object.

3.2 Aperture

The raw image in the leftmost plot of the top row of plots has an option just above it to adjust the threshold for the aperture definition. The aperture is visible as the pixels with black outlines and diagonal lines. The default threshold is 3.0 and typical values range from approximately 2.0 to 10.0 for most stars. Increasing the threshold will generally cause the aperture to shrink in size, and decreasing it will generally cause it to grow. This option allows the user to separate a nearby object from the one of interest or include more pixels for low signal objects.

3.3 Inspection of Data

The two "inspect" buttons in the upper middle of the window allow the user to view two plots more closely and adjust the plot using tools such as zoom and pan. The bottom of these buttons, "Inspect Phased Plot", opens the plot labeled "13" in Figure 2 in a new window. An example of this new window is shown in Figure 3. The toolbar is along the bottom of this new window, and allows the user to make adjustments to get a better view of the data presented in this plot. This is useful when deciding if the phased plot is "OK" (an option in region 14 of Figure 2).

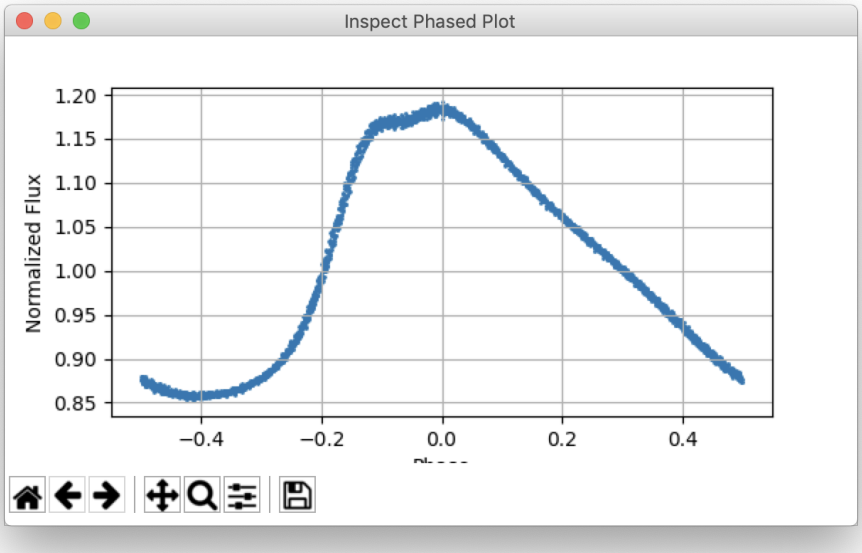

Figure 3: A screenshot of the plot presented when the "Inspect Phased Plot" button is pressed in the main window.

The upper "inspect" button has more functionality associated with it. This button also opens a new window, but two plots, two buttons, and a text box are in this new window. Figure 4 shows an example of this window. The upper plot displays the full lightcurve for the object. Initially, the bottom plot is identical except in the color of the points. By clicking and dragging in the upper plot, one is able to select a region of the lightcurve. The upper plot will have a red shaded region corresponding to the mouse clicks. Once a selection is made, the bottom plot updates to be only that region for a better view of what has been selected, and an entry is placed in the text box on the righthand side. One may select as many regions as desired with any number of data points

included. To aid in selecting very small regions with only a few points, one can use the toolbar at the bottom to zoom and pan the upper plot. After selecting a tool, mouse clicks in the upper plot perform the action of that tool and do not select a region of the lightcurve. In order to again select regions of interest, one must click again on the tool in the toolbar to deselect that tool and go back to the region selection mode. To view a previously selected region, one must simply click on the entry in the text box and that region will be highlighted in green in the upper plot. Once all regions

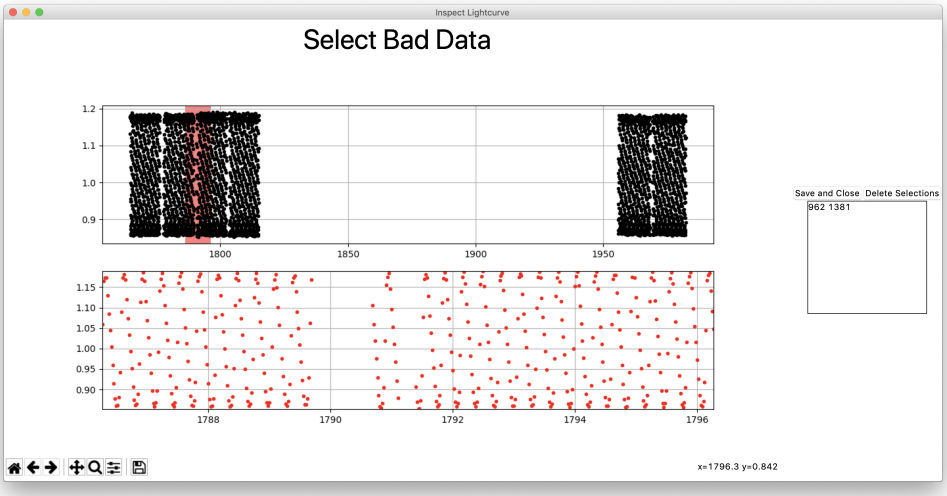

Figure 4: A screenshot of the window used for selecting "bad" data. This window appears when the "Inspect Lightcurve" button is pressed.

considered to be "bad" data have been selected, clicking on the "Save and Close" button will close the window and update the plots and analysis in the main window, eliminating the data points that have been selected. If one would like to add more selections, or delete all selected regions, clicking again on the "Inpect Lightcurve" button will reopen the window and show the currently selected regions in the text box. To delete all regions and display all the available data, click on "Delete Selections" and then on "Save and Close" and all the original data will be displayed.

The process of selecting and/or deleting regions to eliminate from the plots and analysis can be repeated any number of times until a satisfactory result is obtained.

3.4 Radio Buttons

The selections in region 14 of Figure 2 are used to categorize the object being displayed. Currently, these options are specific to RR Lyrae type variables and interesting features found in their lightcurves. Only one option can be selected per group, but an option need not be selected to save the object and move on. All selections are saved in the output file.

3.5 Output

The generated output of the GUI is a table of information saved in the fits format. The filename has the same root name as the input file, with ".fits" appended to the end. Information on each object seen and saved in the GUI includes the selections made in the main window (specific RR Lyrae type, aperture quality, etc) as well as values calculated from the lightcurve (such as period,

amplitude, etc). One can view the information saved in the output file with a program such as TOPCAT[4].

4 Typical Workflow

A typical workflow for using this GUI on a sample of known or suspected RR Lyrae stars would look like the following.

- Create a list of objects using a text editor
  - Make sure there is NO header
  - The first two columns MUST be RA and dec
  - Any number of columns may be included
  - Character between columns can be: space, tab, or comma
- Start the GUI using the example.py file
- Input the list of objects using the "Open File" button and dialog
- Eliminate any "bad" or "problem" data in the lightcurve using the "Inspect Lightcurve" functionality
- Use the plots presented in the main window to make selections in the bottom portion of the window (more information on this step can be found in the Guidebook)
- Type any comments/issues/problems with the object in the Notes box at the very bottom of the main window (this entry has a limit of 250 characters that are saved in the output)
- Click on "Save This Star" in the upper middle portion of the GUI to record the information on this object and move on to the next
- Progress on the input list is visible in the text box on the right of the main window (all previous stars as well as the currently visible star are highlighted and the GUI moves through the list from top to bottom)

5 Conclusion

The main framework of this GUI is a blunt object meant to extract meaningful information from RR Lyrae stars in the *TESS* data archive of full frame images in a timely and efficient manner. Functionality has been added on top of this to adjust certain things and eliminate any data that is obviously bad. Options for flagging a small subset of interesting features has also been included to aid in identifying interesting objects for more detailed followup analysis.

This interface is meant to present information in a meaningful way that can be used to quickly and easily make decisions and find information about these objects. The learning curve for running the GUI should be very shallow. Interpreting the information presented is more difficult, but the included Guidebook should aid in knowing what types of things to look for and what things are most important.

Obviously, this GUI is specific to RR Lyrae types, but with minimal effort it could be modified to work for other, similar pulsating variables (such as Delta Scuti and Cepheid types).

[4] http://www.star.bris.ac.uk/~mbt/topcat/