Analysis of the ROTSE I Data to Create an Unbiased Survey of Variable Stars

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Abstract

Eclipsing Binary systems are two stars orbiting around their center of mass at an angle such that the eclipse is visible from Earth. These systems can be used for distance measurements and are the only systems for which direct mass measurements can be made. This makes statistical analyses on these stars very valuable. In order to determine the location, orbit characteristics, and behavioral physics behind these systems through statistical analyses, an unbiased survey of variable stars seen by the ROTSE I telescope was constructed. This was done by filtering light curves and code development.

Introduction and Motivation

Eclipsing binaries are useful objects the study of which is far from complete.[1] In researching these objects, many aspects of the universe can be understood.

The Variable Star Project's (VSP) efforts regarding eclipsing binary systems have been limited to discovery analysis including the classification and determination of periods and amplitudes.

Statistical analyses that could provide further insight cannot be performed on the discoveries sample because it is biased to only the stars that were accredited discoveries to the ROTSE telescopes.

The goal for this project was to complete a first-pass census of the candidate variable stars in the ROTSE I data to compile an unbiased survey for such analyses.

Apparatus

VSP collects and analyzes data from the "Robotic Optical Transient Search Experiment (ROTSE)" telescopes. ROTSE I specifics:

- 4 co-mounted CCD cameras capture light and convert to digital data
- Field of view is 8 degrees of the night sky per camera
- Limiting magnitude (faintest magnitude detectable) is about 15 for a 5 second exposure
- Filters are not used by the telescope
- Data scheduled every minute each night for uninterrupted light curves

Sample Selection

There is not code that can select only candidate variable stars in the data. Therefore, the data was surveyed by hand. The existing code can select objects that are statistically different than constant by applying three filtering cuts:

- Delta magnitude: difference in magnitude between the brightest and dimmest point of at least 0.1.
- Maximum Significance: the significance of maximum variation of at least 3.0.
- Minimum Chi-Squared value: goodness of fit between observed values and theoretical expectation of at least 2.0.

After these cuts are applied, objects determined to be candidates were those in which the most points were confirmed by being contiguous in time, consistent with other points, and which had continuity showing and overall trend.

Figure 1 shows an example of a light curve that resulted after these cuts were applied.

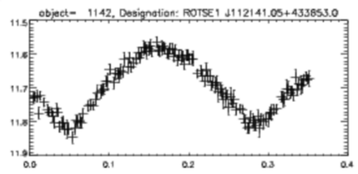


Fig. 1. This light curve is an example of a confirmed, consistent, and continuous light curve.

Once an object was identified on multiple nights, these light curves were phased to find the ROTSE I determined period and amplitude. See Figure 2.

Phasing uses cubic spline fitting to compile light curves that show parts of a cycle until the fit with the least scatter and best period is found, to construct a continuous light curve.

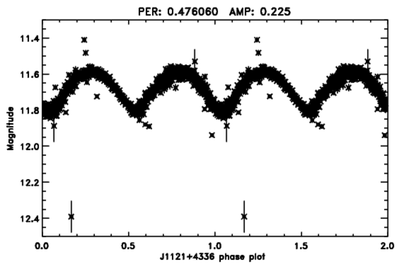


Fig. 2 The phased plot of Figure 1.

Results

303 candidates were identified. The classifications of these candidates were determined by searching each object in the Variable Star Index (VSX). (Figures 3 and 4)

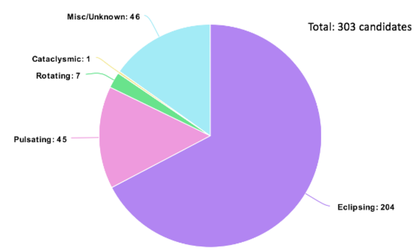
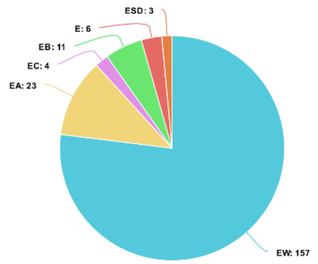


Fig 3. Classifications of variable candidates surveyed according to VSX.

These results were further categorized into eclipsing subtypes shown in Figure 4.



Fig, 4. Subcategories of eclipsing variable candidates according to VSX.

Discussion

It is estimated that most of all stars are eclipsing binaries, and this is reflected in these results as Figure 3 shows that eclipsing systems comprised 2/3 of the survey.

The subtypes are differentiated with differences in period, magnitude, and shape of the light curves.

In Figure 4, the most prevalent subtype is EW (contact binaries). These stars share an atmosphere. In studying their orbit and other behavior, the astrophysics of their atmosphere can be understood.

With this data, possible physical explanations to why EW variables are so common could be explored. Such as analyzing whether they are more common due to their physics or if they are more easily identifiable due to their short periods and almost always visible eclipses.

Conclusions

The goal of compiling an unbiased first-pass census that can be used for statistical analyses was achieved. However, by-hand analyses are inherently full of opportunity for error and this survey could be only a small sample of the variable candidates in the data.

Next Steps

Code that will compute this process is needed.

Preliminary code was written and integrated into the existing code that prints the location and identification numbers to a .txt file for objects found using the cuts.

The completed code will compare objects among several nights. Completion of the code is necessary before further efforts to complete the survey.

Completion of phasing the candidates' light curves is needed to find the ROTSE I classification instead of the VSX data.

Then, statistical analyses will be conducted to make measurements of parameters of stellar systems, distance measurements, and determination of location in the galaxy.

References and Acknowledgements

[1]Latkovic, O.; Ceki, A.; Lazarevic, S. Statistics of 700 individually studied W UMa stars. arXiv:2013.06693v1.

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