Exploring an Improved Method for Determining LSST's Eclipsing Binary Yield

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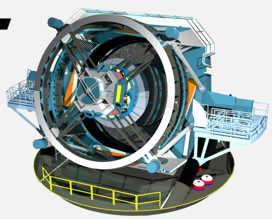
The LSST and Its EB yield as Scientifically Vital

When the Large Synoptic Survey Telescope (LSST) goes online in the early 2020s, it will be uniquely capable of detecting eclipsing binaries (EBs) due to its relatively short cadence, long survey, and large field of view. Because EBs are vital to accurately determining the mass of distant stars (and other important information such as their radius, distance, and luminosity), it is important to understand how many eclipsing binaries LSST will detect and identify and what biases might exist in that detected sample. We explore here, and in future works, a new method to identify and characterize LSST's EB yield that will allow us to examine what factors (different orbital periods, masses, etc.) inform the survey's accurate binary detection.

The Method

Using LSST-like specifications such as cadence, survey time, and apparent magnitude constraints, we can generate theoretical, phase-folded light curves using the Python package ellc (Maxted 2016). These ellc-simulated binaries are then fed through another package, gatspy (VanderPlas and Ivezic 2015), which is unique for its use of a *multiband* Lomb-Scargle periodogram, to attempt identification of the binary's orbital period.

These packages have a combined utility that allows us to assess LSST's binary yield (primarily via ellc) and analyze the variables that impact this yield such as orbital period, mass, apparent magnitude, distance, etc. (primarily via gatspy). The composite code that employs both ellc and gatspy will be the basis of our ongoing look at LSST's EB yield.



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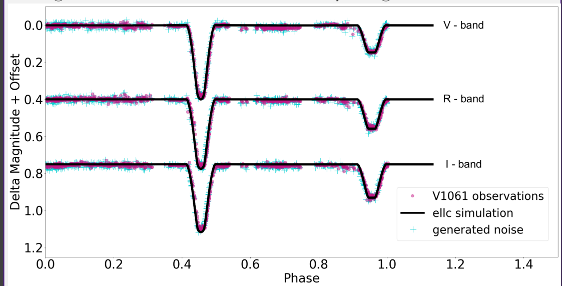
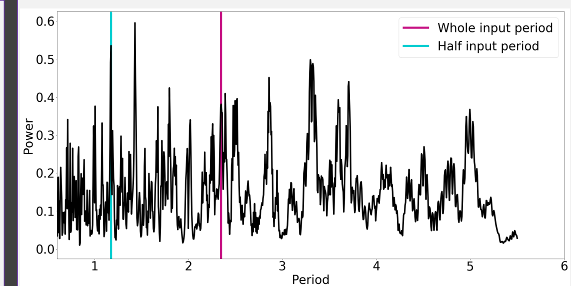
Checking Our Method against Documented Observations

Confirming ellc's function was a matter of comparing its generated light curves to those plotted from real observations, in this case, using the Gettysburg data from the binary V1061 Cygni (Torres et al. 2006). Below, light curves from observations in several pass bands (V, R, and I ; R and I offset for readability) are overlaid with ellc's simulated observations using the true noise levels of the Gettysburg

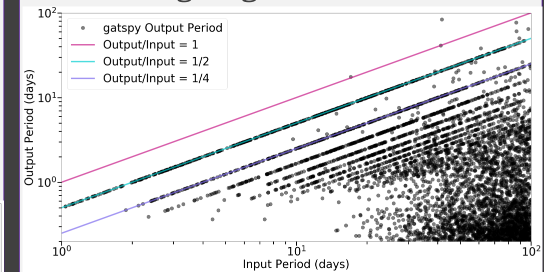


observations. From the above plot, it becomes clear that ellc works completely as intended, generating accurate, usable light curves when provided realistic parameters.

Gatspy requires a much larger sample size to assess. Below is an example of a multiband Lomb-Scargle periodogram, resulting from the same data as the above light curves. Power (plotted against period) is generally at a maximum when the two dips overlap, so it is no surprise that gatspy frequently detects the half period instead of the whole period. However, it is not abundantly clear from the periodogram whether gatspy (and the use of Lomb-Scargle in general) is able to accurately identify the input period. This new consideration, 'how frequently is the period (or half period) accurately identified?' can be addressed with a period-randomized, LSST-like simulation.

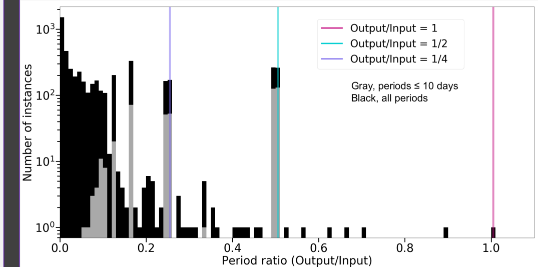


The Future of This Method in Ongoing Research



Using log-scaled axes above, it is obvious that gatspy's performance at small periods, ≤ 10 days, is significantly better than at longer periods. Overall, ~5% of our binaries are correctly identified at the half period; ≤ 10 days, ~1/3 return the half period. This is consistent with prior studies of LSST's binary yield (Wells and Prsa 2017).

In our more thorough examination, we will use a full-scale galactic model to determine a more realistic EB yield. Better understanding the Lomb-Scargle multiband period fits not only aids our future analysis of that yield value, but offers a comparison for the use of other period recovery algorithms.



References

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"Periodograms for Multiband Astronomical Time Series", VanderPlas and Ivezic 2015, ApJ, 812, 18

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