Observations of Kepler Binary Stars

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1 Abstract

The Kepler mission is set to find planets orbiting stars outside our solar system. In 2011, the Kepler mission released a catalog of all the eclipsing binaries that they had found so far. Using this catalog, I sorted the binaries by the depth of its primary eclipse with the idea that a deeper eclipse would result in more notable difference in magnitude. I then wrote a script in Python which would calculate the time and date of the next eclipse for each system. As so many of the systems had periods of less than 1 day, there would often be several eclipses happening in one hour. Observations were made with an Optec SSP-3 photometer on a 16 inch telescope at the Stickney Observatory on the Bennington College Campus. For the first two nights of data collecting, I only observed the counts given from the star. On the third night, I recorded a count of the night sky with no objects in it. No good results were obtained due to several reasons.

2 Kepler Eclipsing Binaries Catalog

The Kepler mission is set to find planets orbiting stars outside our solar system. The area of the sky that it's studying contains over 156,000 stars being observed to find any dips in apparent magnitude which would suggest that there is a planet orbiting the star. As is expected, not all of the stars that feature a dip are due to exoplanets.[1] Many of these stars are eclipsing binary systems - solar systems which are made up of two stars which eclipse one

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[1]Prsa et al (2011)

another when viewed from Earth.

In 2011, the Kepler mission released a catalog of all the eclipsing binaries they had found so far. The catalog, currently on its 3rd version, contains information about the binary's coordinates, the width and depth of the primary and secondary minima, temperatures of the stars, and more.[2]

3 Calculating Eclipse Times

Using the Kepler Eclipsing Binaries catalog, I sorted the binaries by the depth of its primary eclipse with the idea that a deeper eclipse would result in more notable difference in magnitude. From the sorted list, I then selected the top fifty systems which had a period of less than four days. This length of time was chosen because I planned on observing at least three eclipses for several systems within a month time frame.

I then wrote a script in Python which would calculate the time and date of the next eclipse for each system. These times were calculated from the Julian date at which the maximum depth of the primary minima was observed as well as the width of the minima, given in the catalog in terms of days. The time of the peak of the next eclipse was then converted from Julian date to the Gregorian Date in Eastern Daylight Time. The program then wrote a list of the 50 stars sorted by time of the next eclipse to a text file. In addition to the next eclipse, output included the Kepler ID number, the period of the system in days, the apparent magnitude of the system, and its coordinates. A sample of the output can be seen in Figure 1.

4 Data Collection

As so many of the systems had periods of less than 1 day, there would often be several eclipses happening in one hour. This made it easy to catch any of the eclipses as I would wait at most thirty minutes before an eclipse would begin.

Observations were made with an Optec SSP-3 photometer on a 16 inch telescope at the Stickney Observatory on the Bennington College Campus. In-

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[2]The full catalog is online at http://keplerebs.villanova.edu/

KIC	Period	Magnitude	Ra Dec	Next Eclipse
9205993	1.2197374	14.871	19h02m54.096s +45d39m59.04s	2016-05-29 01:09:52.098
9307423	0.5586161	15.792	20h02m22.104s +45d45m27s	2016-05-29 01:20:09.746
6671698	0.4715248	13.489	18h58m47.736s +42d08m48.48s	2016-05-29 01:28:49.424
5881838	0.3003313	14.737	19h34m07.968s +41d08m36.96s	2016-05-29 02:06:50.548
10581918	1.8018631	12.796	18h52m10.488s +47d48m16.56s	2016-05-29 03:25:29.365
7878402	0.3743508	13.388	19h06m22.032s +43d38m09.6s	2016-05-29 03:33:26.435
11341950	0.2883712	14.924	19h09m05.856s +49d11m58.56s	2016-05-29 03:42:35.907
5535061	0.4634302	12.388	19h29m08.808s +40d44m54.96s	2016-05-29 04:11:28.613
10727655	0.3533655	13.433	19h21m43.896s +48d03m57.24s	2016-05-29 05:13:30.139
10275747	0.6617485	12.796	19h30m09.24s +47d21m51.84s	2016-05-29 05:46:48.688

Figure 1: Sample output of the program which would calculate the times of the next eclipses.

tegration time was set to 10 seconds and the gain set to either 10 or 100. I aimed to record the total count around every 5 minutes.

For the first two nights of data collecting, I only observed the counts given from the star. On the third night, I recorded a count of the night sky with no objects in it.

5   Results & Discussion

No good results were obtained. This was caused by several reasons:

1. There were few days in May with clear skies. Of the days with clear skies, I was only able to observe during some of them.

2. Many of the stars I chose had magntiudes of over 14, and often times the stars were not the brightest stars in the field. This made it difficult to know which star I was looking at and even when I did have a good idea of which star it was, I often could only see the star with my peripheral vision because it was so faint. For the observations made on June 1, 2016, I could not see the star at all and had to trust that the telescope was pointing at the correct object.

3. On the three nights that I was able to find what I believe to be the star and was able to center it and gather data, the moon rose during observations and caused the sky to become brighter. The result of this was that instead of observing a decrease in total counts in the
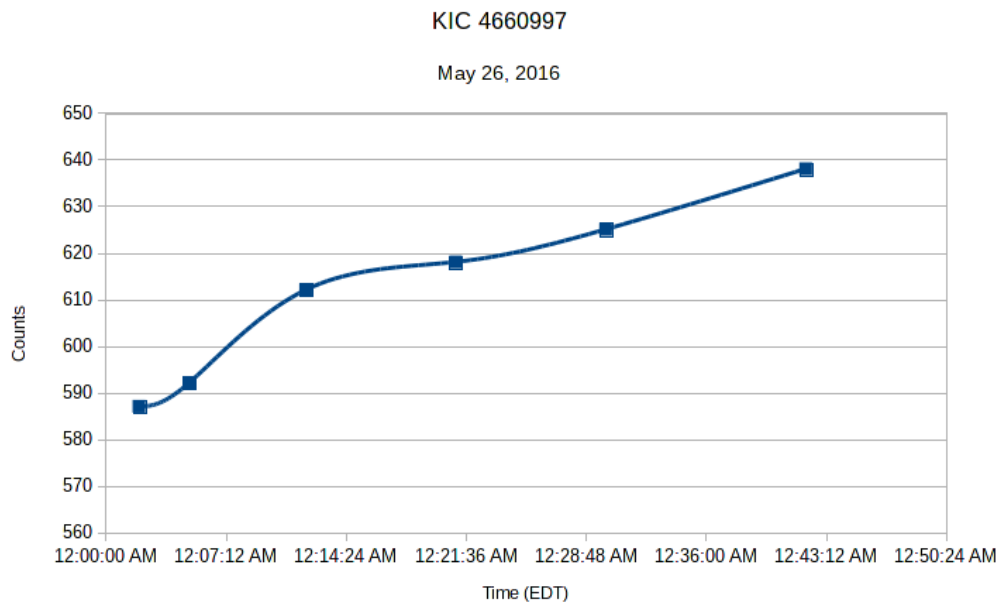
KIC 4660997

May 26, 2016

Figure 2: Observations made on May 26 starting at 12:02 am EDT. The maximum depth of the eclipse was scheduled to happen at 12:23 am EDT and has a magnitude of 12.37. The gain on the photometer was set to 10 and integration time to 10 seconds. The moon started to rise at 12:00am, right when I started observations.
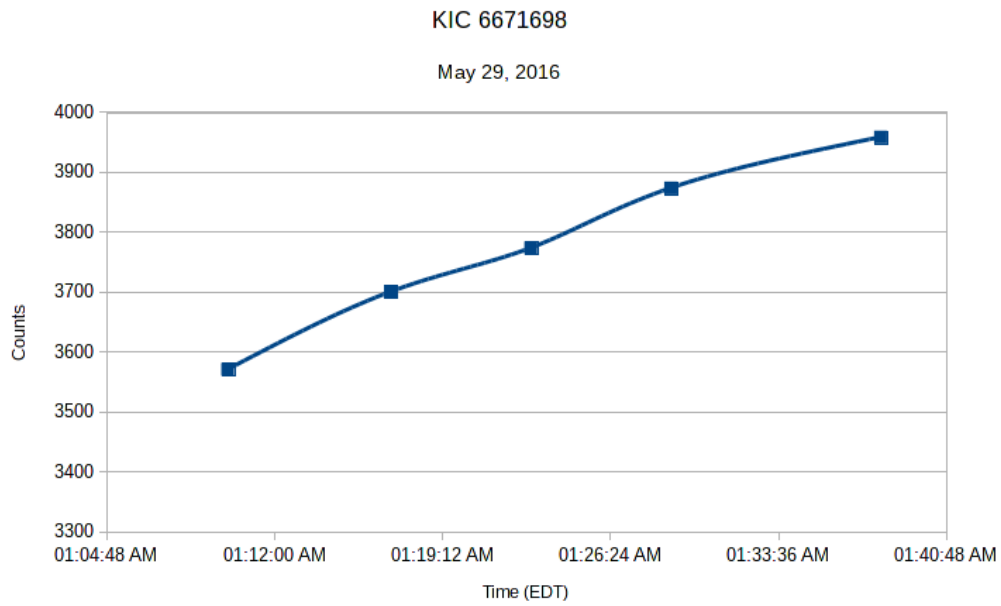
KIC 6671698

May 29, 2016

Figure 3: Observations made on May 29 starting at 1:10 am EDT. The maximum depth of the eclipse was scheduled to happen at 1:28 am EDT and has a magnitude of 13.5. The gain on the photometer was set to 100 and the integration time to 10 seconds. The moon started to rise at 1:22am, once again right around when I started to observe.
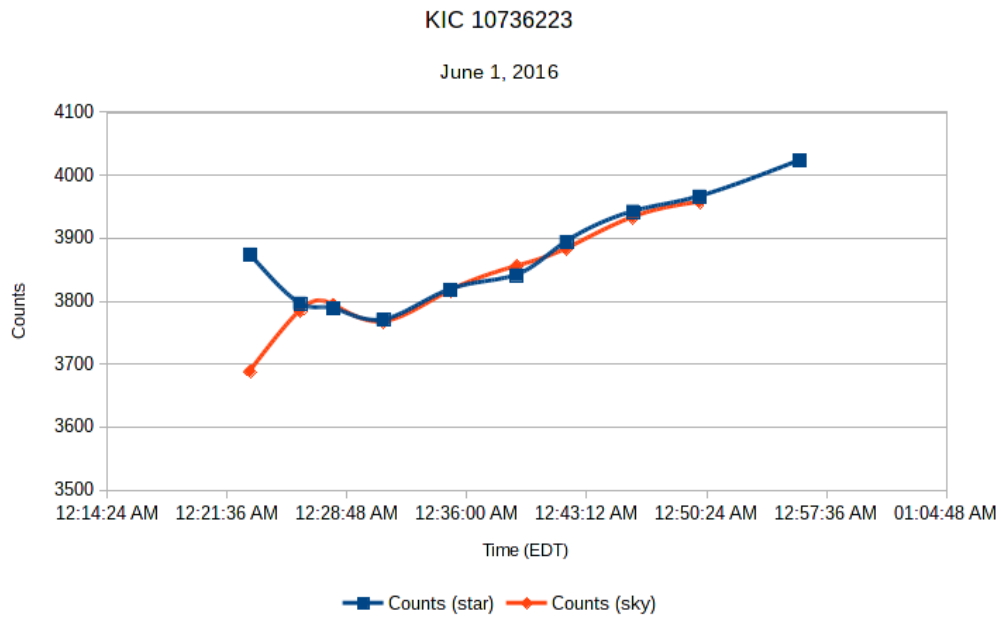
KIC 10736223

June 1, 2016

Figure 4: Observations made on June 1 starting at 12:23 am EDT. The maximum depth of the eclipse was scheduled to happen at 12:28 am EDT and has a magnitude of 13.7. The gain on the photometere was set to 100 and the integration time to 10 seconds. The moon was scheduled to rise at 3:05 am - this leads to the question as to why the counts even for the sky continued to steadily rise.

photometer as expected, what happened instead was that the counts continued to rise throughout the primary minima.

There were several things that could have been done differently in order to obtain better results:

1. There isn't much that can be done about cloudy days, other than not living in New England.

2. When choosing the stars to use, an additional parameter could have been the magnitude of the star. Additionally, the program I wrote to calculate the eclipse could be easily modified to automatically choose stars from the entire list making it easier to specify multiple criteria such as Period < 4 and Magnitude > 13.

3. On the third attempt at observing, I gathered a reading of the night sky with no stars in the field of view. This made it so that I could calibrate the star against the dark sky making it so that outside influences, such as the moon, didn't have as much of an impact. This process should have been applied to the other nights of observations.

Figures 2-4 plot the number of counts I obtained during each night of observations and at what times. Figure 4 is the only plot out of the three which displays a dip in overall brightness around where the maximum depth was expected to happen.

6 Citations

Prsa, Andrej, Natalie Batalha, Robert W. Slawson, Laurance R. Doyle, William F. Welsh, Jerome A. Orosz, Sara Seager, Michael Rucker, Kimberly Mjaseth, Scott G. Engle, Kyle Conroy, Jon Jenkins, Douglas Caldwell, David Koch, and William Borucki. *Kepler Eclipsing Binary Stars. I. Catalog And Principal Characterization Of 1879 Eclipsing Binaries In The First Data Release.* The Astronomical Journal 141.3 (2011): 83. Web.