Project 2: Exoplanet Transit

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1. OBSERVATIONS

The transit we chose to observe was that of WASP-183 b. We chose this due to the brightness of the target star, depth of the transit, and the relatively short transit time of 2 hours which would keep our observing time down to something more manageable. We decided on using 120 second exposures in the I band. We chose this because we calculated such an exposure time would give us the S/N ratio we needed to detect the transit. We elected to use I band to cut down on interference from the moon. We observed on the night of 3/9/2020, taking 52 shots in total, which gives us a time on-sky of 104 minutes. However, the time of the observations spanned from 30 minutes before to 30 minutes after the transit. A sub-array of 2048x 512 was used on the majority of the images to shorten readout times.

When using the mores command to take shots we did not re-track the telescope while the CCD was reading out. This caused a slow drift of the target in each image in the batch indicated by the mores command, causing us to lose some potential target stars as they would leave the image or be partial cut off. This would make later differential photometry measurements less reliable. There was also mild cloud coverage the night of which may have introduced some more noise to the data.

2. RESULTS

A full frame master I flat and master bias were created and then the appropriate sub-frames were taken from this to be applied to the images. After this processing each image was uploaded to Astrometry to get WCS solutions. These were then used to reproject shots so that all shots were aligned. I then used the same shot that everything was reprojected onto as my detection image in SourceExtractor and passed all the images through SourceExtractor to get the fluxes for each star in the image. The import SourceExtractor parameters I used were a DETECT_MINERA of 10, a DETECT_THRESH of 3.5, and a PHOT_APERTURES value of 10. For the fluxes and flux errors, I read the fluxes from the FLUX_AUTO and FLUXERR_AUTO columns for each star. Three images failed on Astrometry so I had to do a separate SourceExtractor run for each one of these and stitch them into the data at the appropriate place.

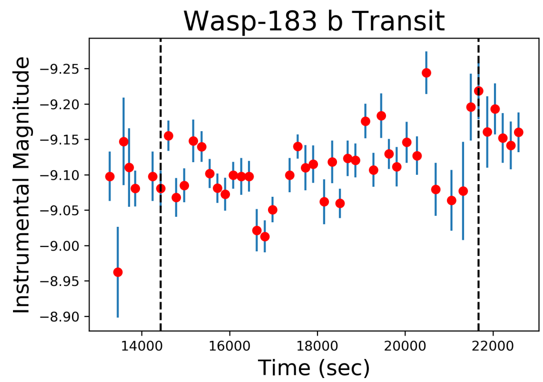


Figure 1. Transit of Wasp-183 b. Dashed black lines indicate the approximate start and end of the transit.

I then converted each flux to a magnitude and proceeded with differential photometry. I was able to determine three calibration stars that were reliably present across all the shots, two of which had magnitudes very similar to the target star and one that was about 1.5 magnitudes brighter. To create the initial difference array for each calibration star, I subtracted from the magnitude of each star the value of the magnitude of the apparent brightest shot in the image. I then took the mean of these difference arrays to produce the differential photometry calibration array that I then subtracted from the initial magnitudes to produce the corrected magnitudes. I then correlated each shot with its timestamp and graphed each one. Unfortunately, it appears that we were not able to pick up the transit in a great degree of detail as can be seen in Figure 1. Therefore for further interpretation of the data I turned to the literature.

3. DISCUSSION

The time of transit is about 2 hours with a 2% reduction in flux [1]. The star Wasp 183 which the planet orbits has a radius of $0.871 R_{sun}$. This corresponds to Wasp-183 B having a radius of $R = \sqrt{\Delta F R_s^2} = 0.123178 R_{sun}$.

The formula for the impact parameter is given by $b = \frac{a \cos i}{R_s}$, where a is the radius of the orbit and i is the

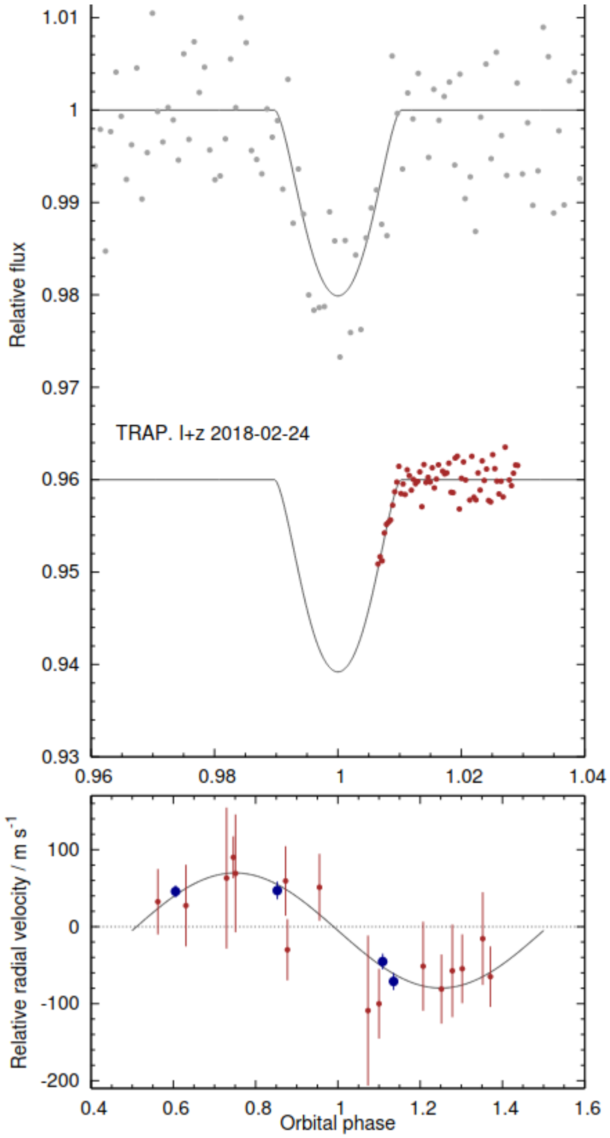
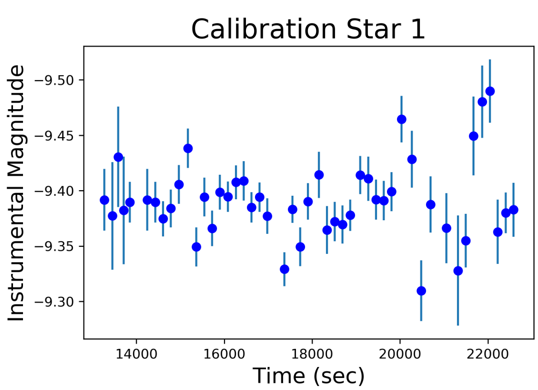
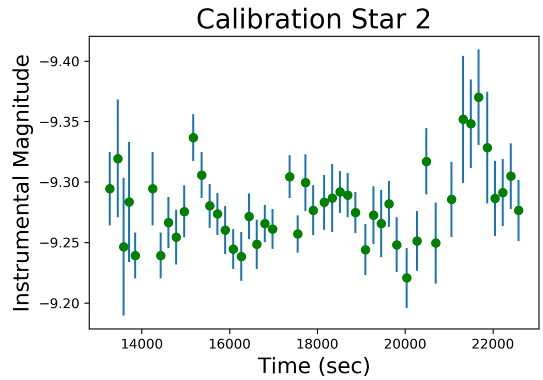
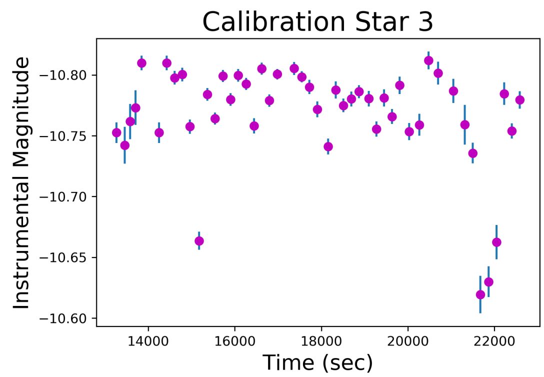


Figure 2. Light Curve of Wasp-183 b from Turner et al 2019







angle of inclination. To determine the impact parameter I would look at the graph of the light curves provided in the slides to find a rough estimate. Figure 2 shows the light curve from the literature. It appears rather sharp which corresponds with the light curve in the slides for b=0.9. For Wasp-183 b, the impact parameter is given to be b=0.916 [1], which means the planet passes pretty close to the edge of the stellar disk.

References

[1] Oliver D. Turner et al. “Three hot-Jupiters on the upper edge of the mass-radius distribution: WASP-177, WASP-181, and WASP-183”. In: *MNRAS* 485.4 (June 2019), pp. 5790–5799. DOI: 10.1093/mnras/stz742. arXiv: 1903.06622 [astro-ph.EP].