A Radius Determination of Exoplanets and the Typicality of Earth

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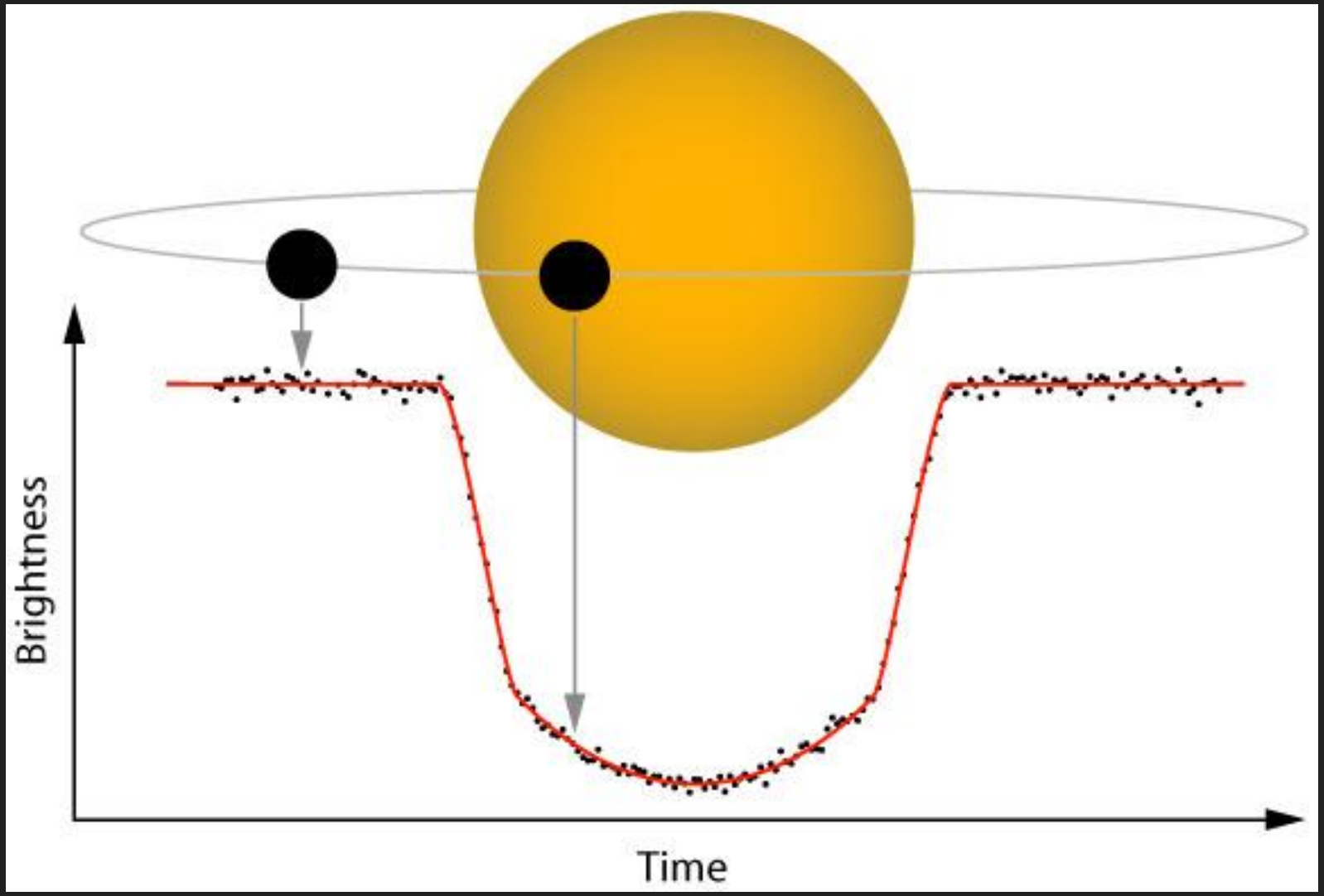


Figure 1: The transit method of detecting and imaging exoplanets[1]

1: Introduction to Differential Photometry. (2013, February 18). Retrieved November 1, 2015.

Table 1: Observational Circumstances for Observed Exoplanet Transits at Wallace Astrophysical Observatory in September and October [1]

Date (EDT)	Transit	Apparent Magnitude (R)	Delta Magnitude (milimags)	Elevation (start, mid, end)	Time (EDT) (start, mid, end)
9/14/2015	Tres-3 b	12.1	29.3	37°, 30°, 24°	22:44—23:24—00:04
10/5/2015	Tres-1 b	11.2	19.8	53°, 39°, 26°	22:01—23:16—00:31
10/16/2015	Kepler-6 b	15.6	10.4	72°, 52°, 34°	20:25—22:23—00:21
10/25/2015	Kepler-45 b	15.7	34.2	77°, 71°, 65°	20:53—21:25—21:57

1: This research has made use of the VizieR catalogue access tool, CDS, Strasbourg, France. The original description of the VizieR service was published in A&AS 143, 23

2: The USNO-A2.0 Catalogue. (1998). Retrieved November 1, 2015.

Table 2: Comparison Star Specification for Transit Star Fields[1]

Transit	Target Magnitude (R)	Magnitude (R)
Tres-3 b	12.1	13.4
		13.9
		13.0
Tres-1 b	11.2	12.8
		11.2
		10.7
Kepler-6 b	15.6	14.4
		12.6
		14.0
Kepler-45 b	15.7	15.1
		15.4
		14.9

1: The USNO-A2.0 Catalogue. (1998). Retrieved November 1, 2015.

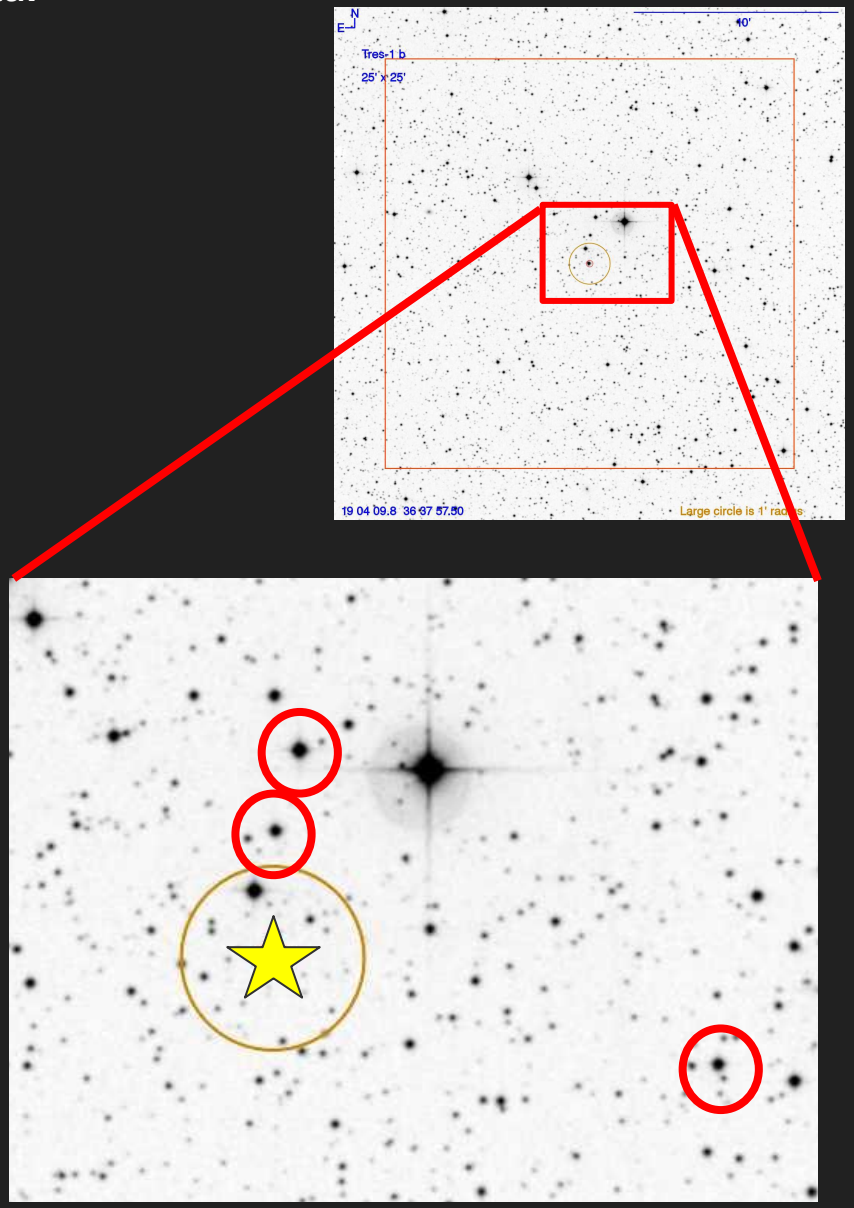


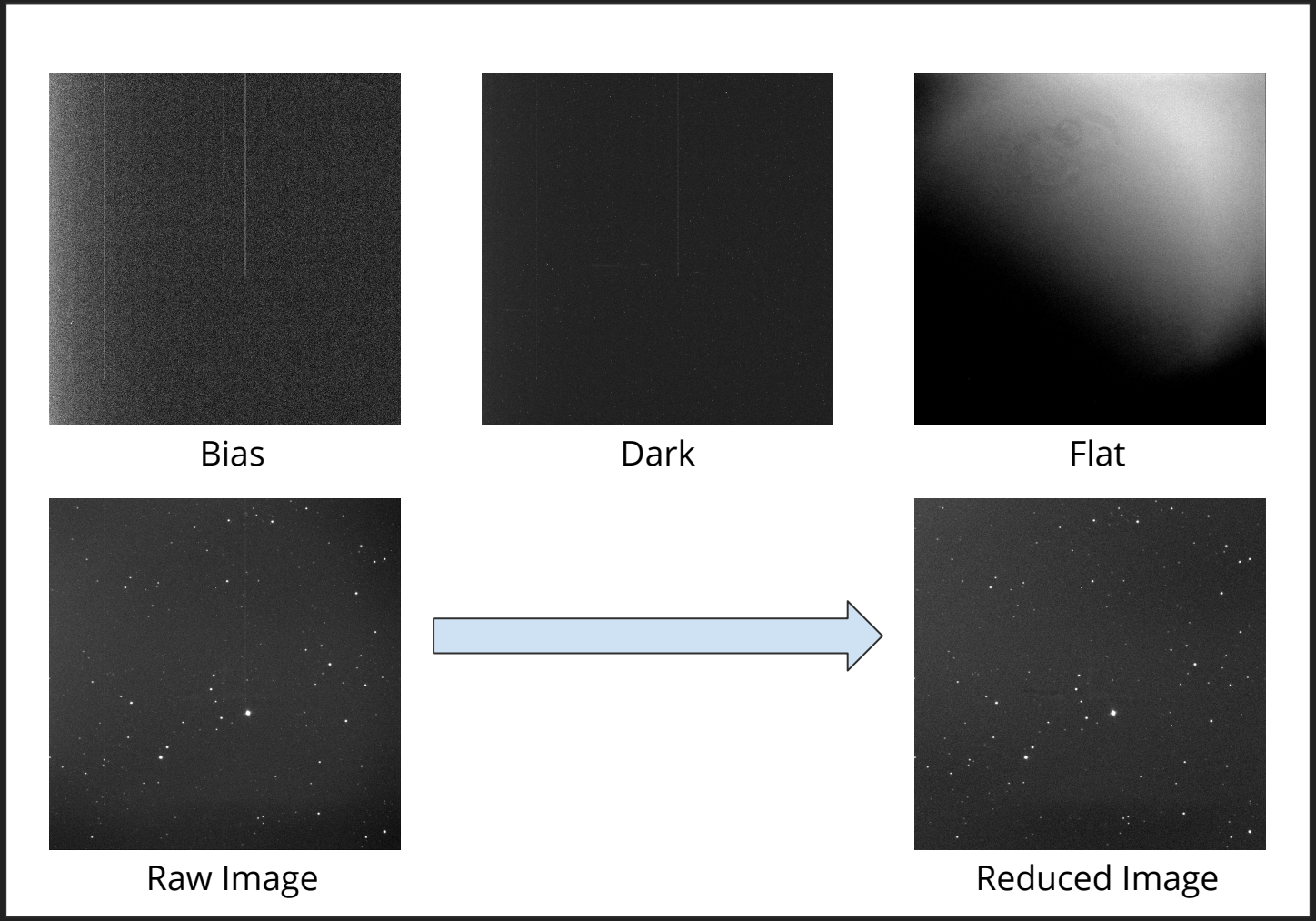
Figure 3: Tres-1 b finding chart and detail

Table 3: Data Taken at Wallace Astrophysical Observatory in September and October 2015

Transit	Date (2015) (EDT)	Frame	Data Amount (Images)	Weather	Telescope
Tres-3 b	Sep. 14	Light	382	Clear	Ealing 16in
Tres-1 b	Oct. 5	Light	354	Clear	Ealing 16in
Kepler-6 b	Oct. 16	Light	716	Clear	14in Celestron
Kepler-45 b	Oct. 25	Light	173	Cloudy	14in Celestron

- All data taken in the R filter
- 10 Bias frames taken at the beginning of every night
- 10 Dark frames taken at the end of every night

Figure 3: Calibration images and reduction process using dark/bias subtraction and flat division.



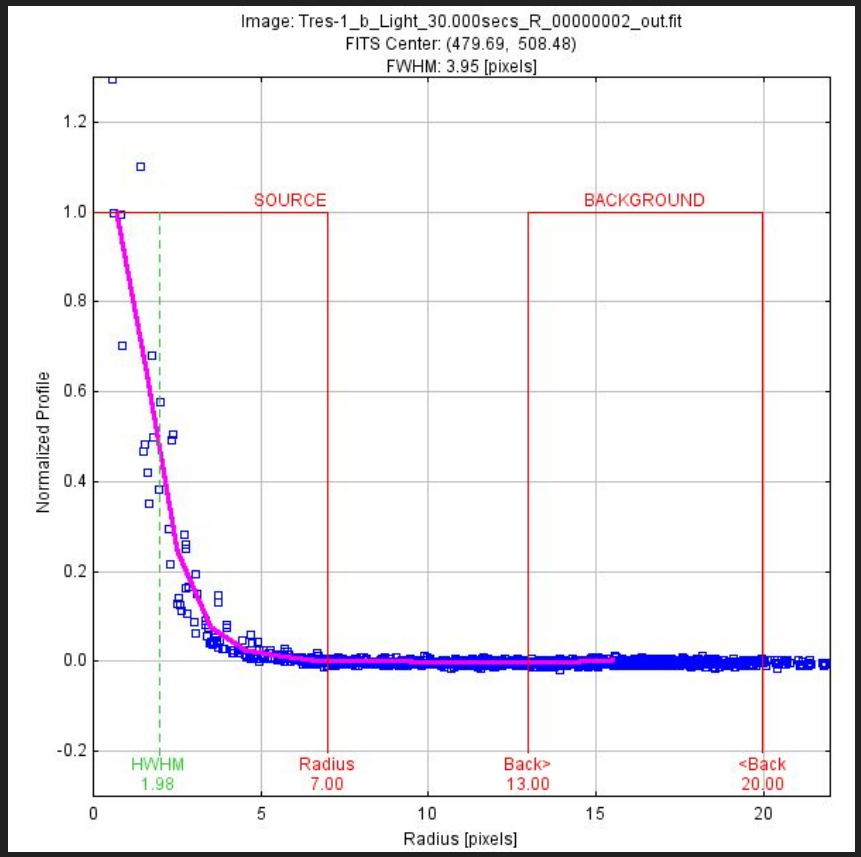


Figure 4: Seeing profile and aperture/annulus radii for Tres-1 b

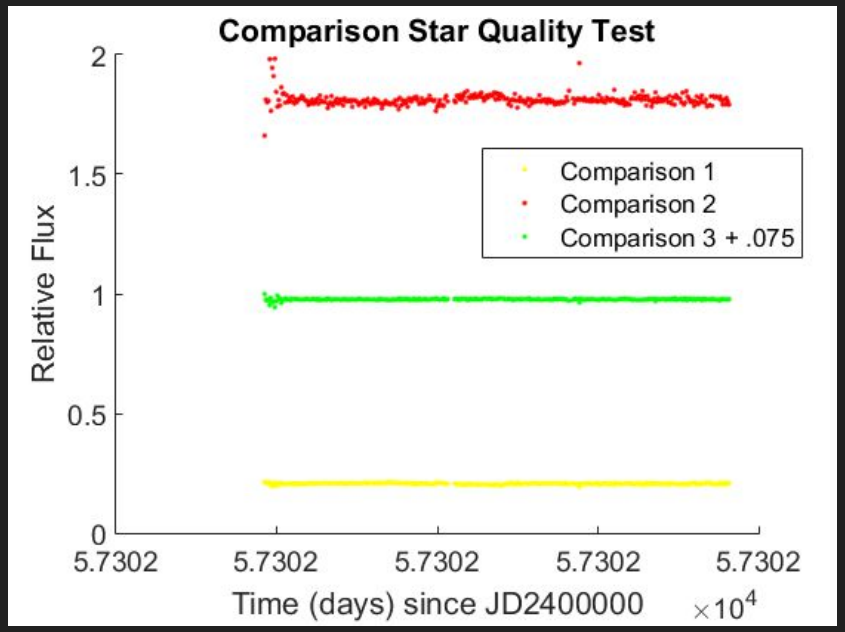


Figure 5: Comparison star quality test for Tres-1 b to determine flux uniformity

- Multi-Aperture Photometry using circular apertures with concentric background annulus

Figure 6: Tres-3 b Transiting Exoplanet

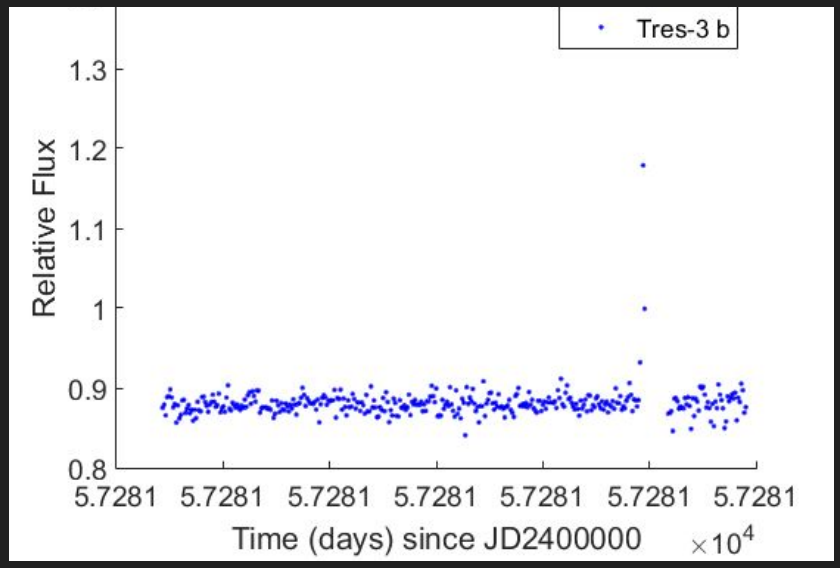


Figure 7: Tres-1 b Transiting Exoplanet

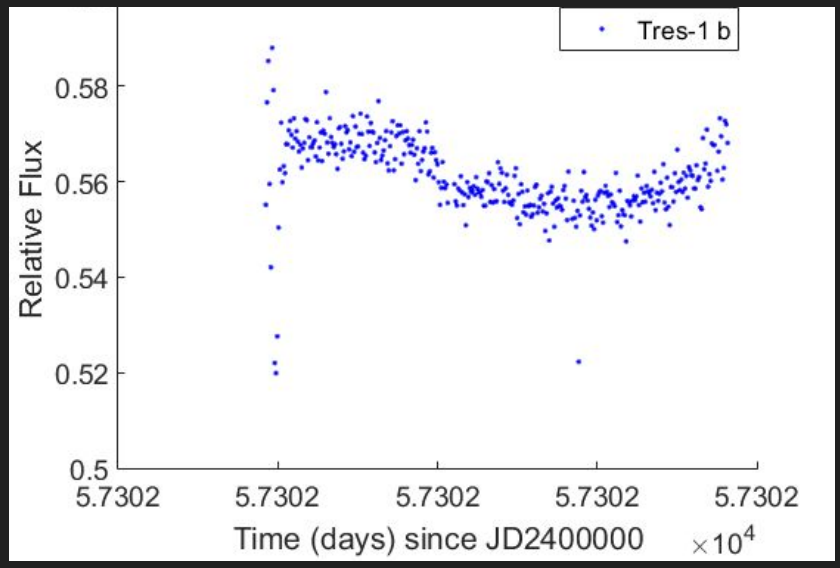


Figure 8: Kepler-6 b Transiting Exoplanet

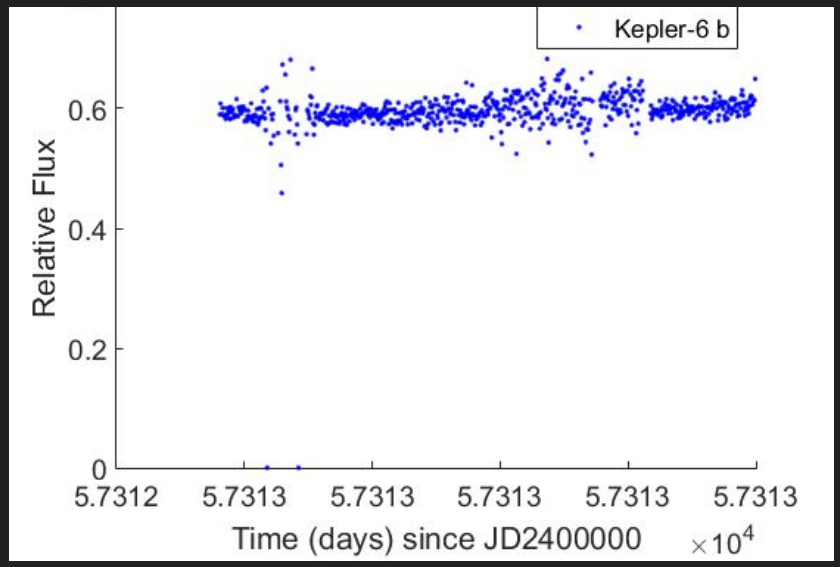
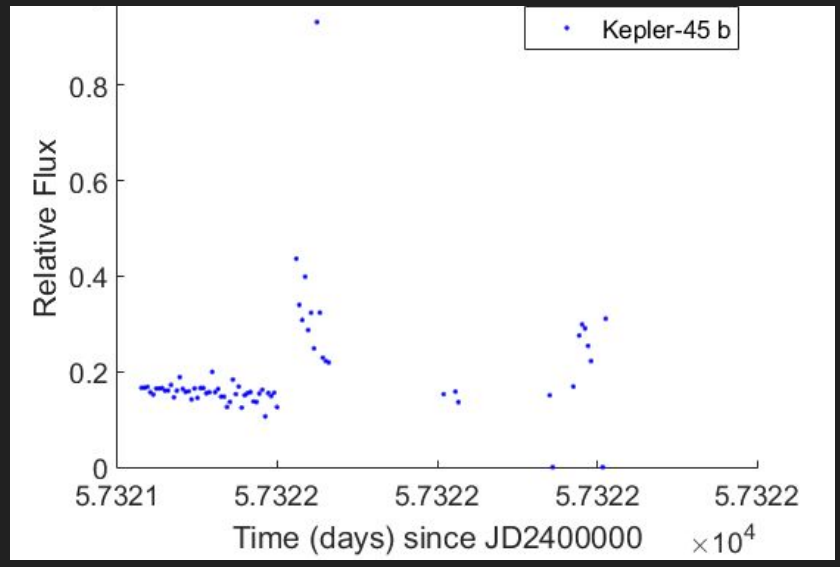
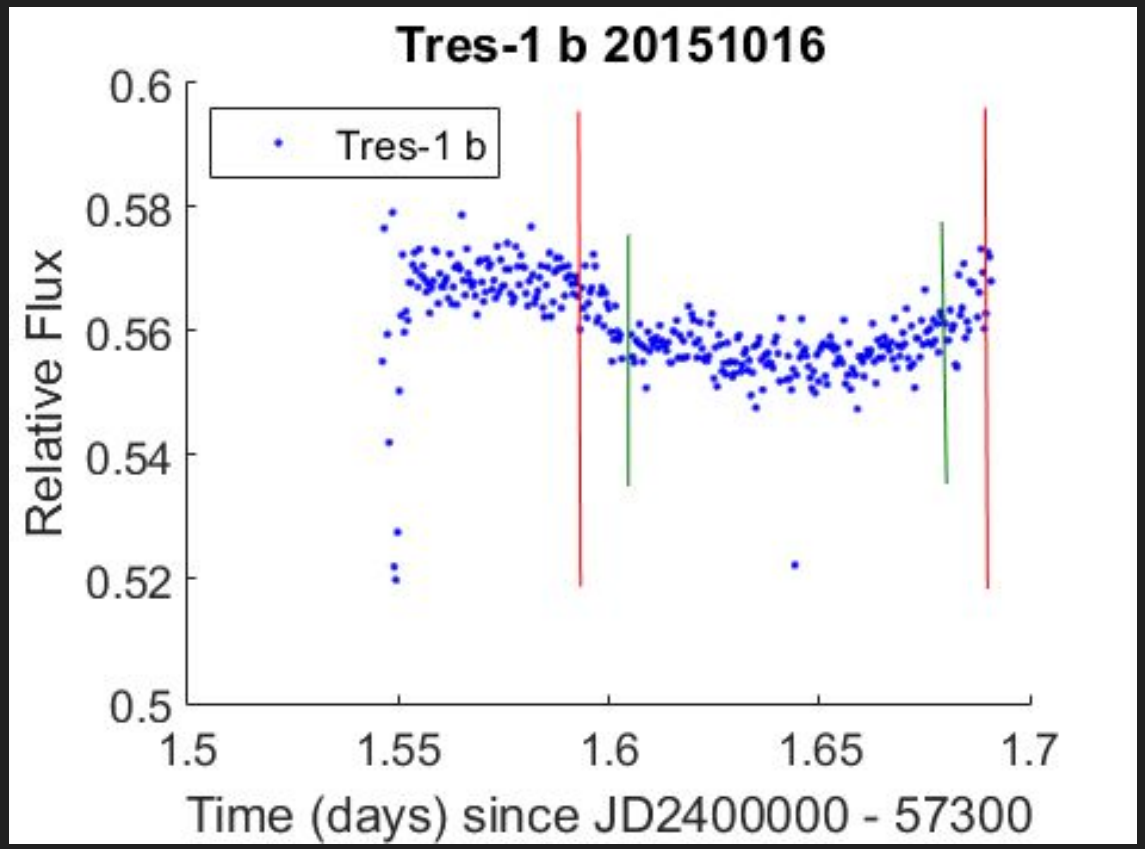


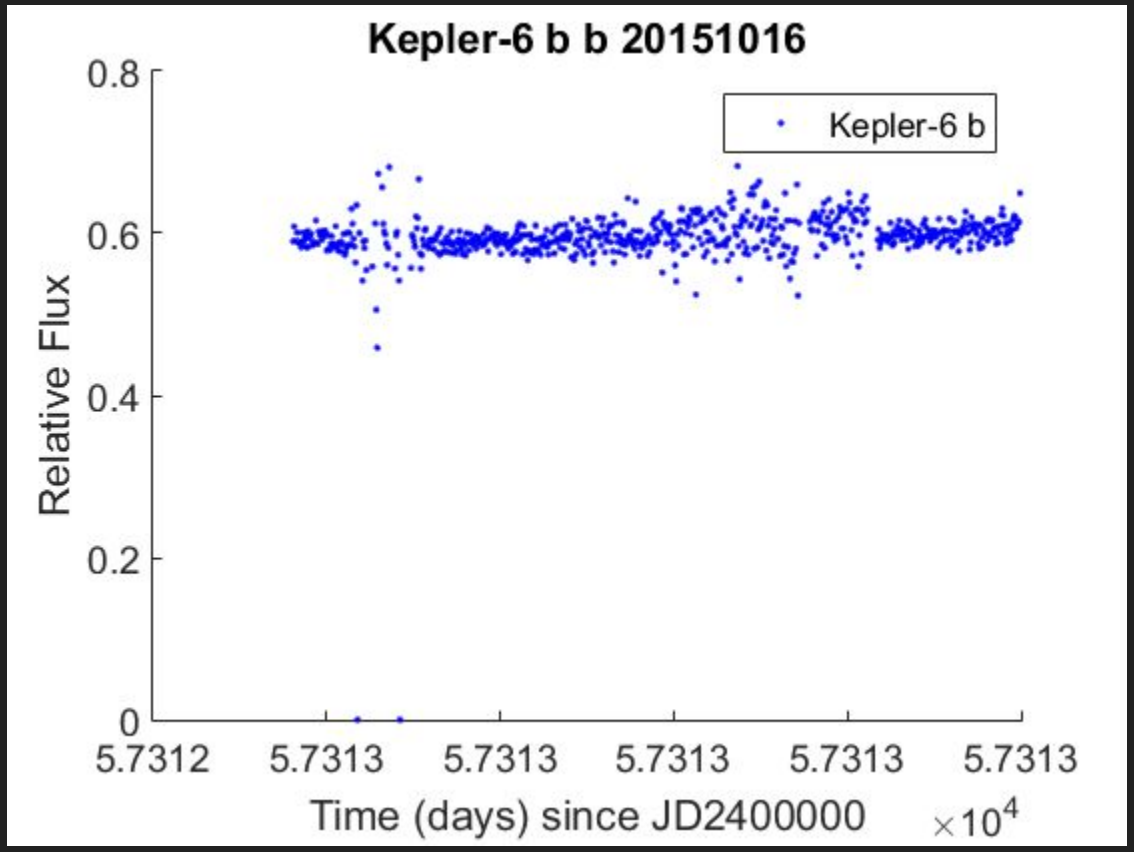
Figure 9: Kepler-45 b Transiting Exoplanet





$$\Delta f = \left(\frac{r}{R}\right)^2$$

- 92% certain from Student's t Test
- Depth of transit: 0.0059 +/- 0.0042
- 0.62 $R_{Jupiter}$ +/- 0.27



$$\Delta f = (\frac{r}{R})^2$$

- Standard deviation of set is 0.039
- Maximum radius: 0.87 $R_{Jupiter}$

Conclusions

Two hypotheses:

- Exoplanets are comparable to Jupiter in size and Earth is atypical

- The types of planets the transit method can detect are comparable to Jupiter in size