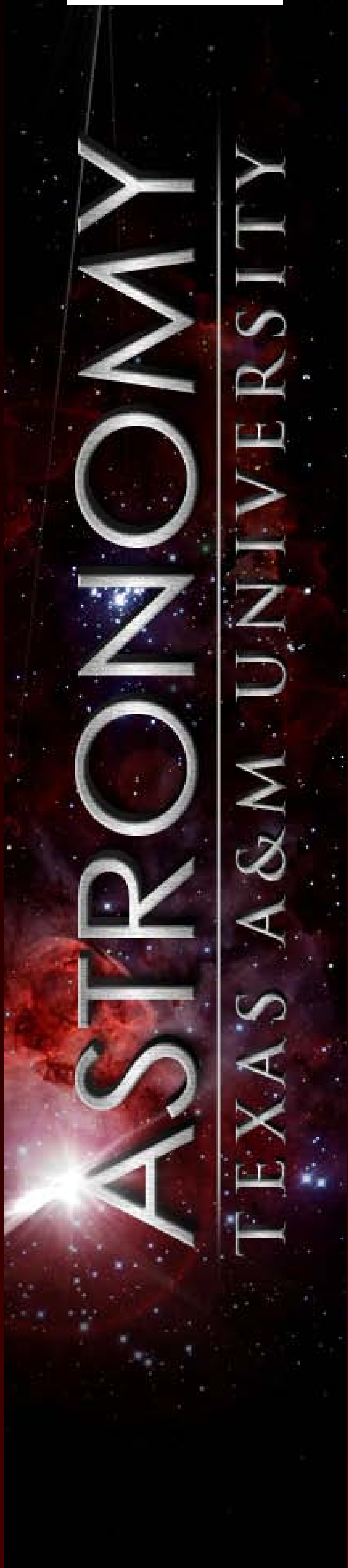


The Statistical Significance of Planetary Transit and Occultation Detections at Dome A in Antarctica

R. J. Oelkers, D. L. DePoy

Department of Physics and Astronomy, Texas A&M University, 4242 TAMU, College Station, TX, USA 77843-4242

ABSTRACT

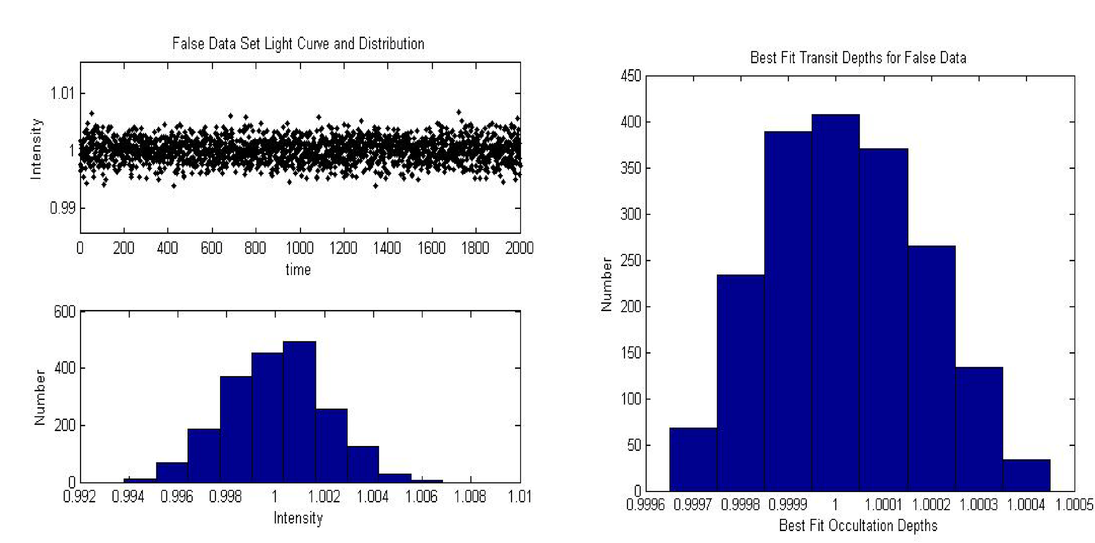
The increased discovery of planets through transit detections has created a demand for the characterization of exoplanets. By using an occultation detection, one can extrapolate the properties of a planet not found by other techniques. Using occultation measurements can greatly impact the effort of finding Earth like planets in other solar systems. Unfortunately, many of these occultation measurements are weakly detected, giving reason to question the validity of the detection. We provide a simple approach to determine the statistical significance of an occultation or transit like detection. We employ a chi-square goodness of fit to multiple eclipse depths and eclipse times. This allows us to remove the bias associated with an assumed detection time and eclipse depth. Systematic error can be easily identified because if no eclipse is detected the expected output for the best fit depth will be Gaussian around the normalized flux of the light curve. Thus providing a more accurate description of whether or not the detection could be random noise or an actual event. Using data from the Antarctic telescope at Dome A (Wang et al. 2011) we are able to confirm the detection of a transit like event at a statistical level of 4 sigma.

PLANET STATISTICS

Name	Orbital Period (days)	Transit Length (hours)	Transit Depth
CSTAR 072350	9.91601	9.6	0.2%
Kepler 4	3.21346	3.62	0.074%
Kepler 14	6.79012	6.86	0.227%

EXPECTED RESULTS

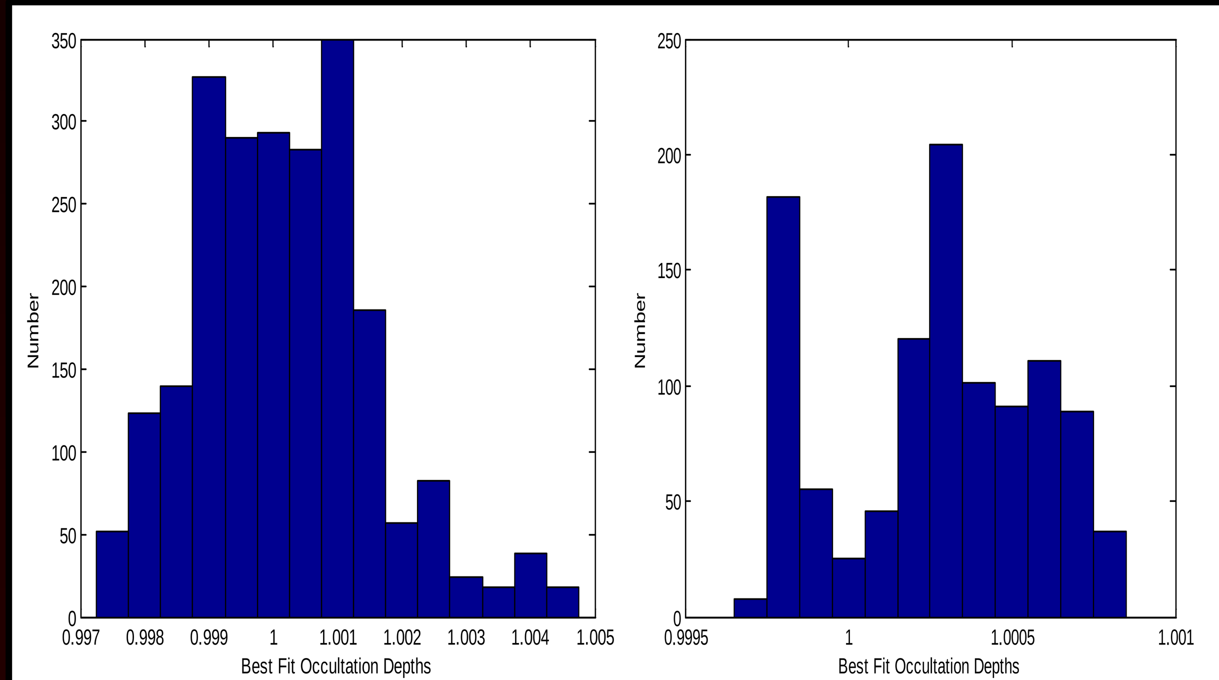
A data set without an eclipse would be expected to show a best fit light curve depth centered around the mean magnitude or normalized flux. There is no eclipse to influence the data and therefore, assuming the star is not variable, the light should remain constant. With simulated data we were able to show this result.



Left Figure: Simulated data light curve without a transit and distribution of data around the mean. *Right Figure:* Best fits results showing a Gaussian centered at the mean of the data.

TRANSIT DURATION

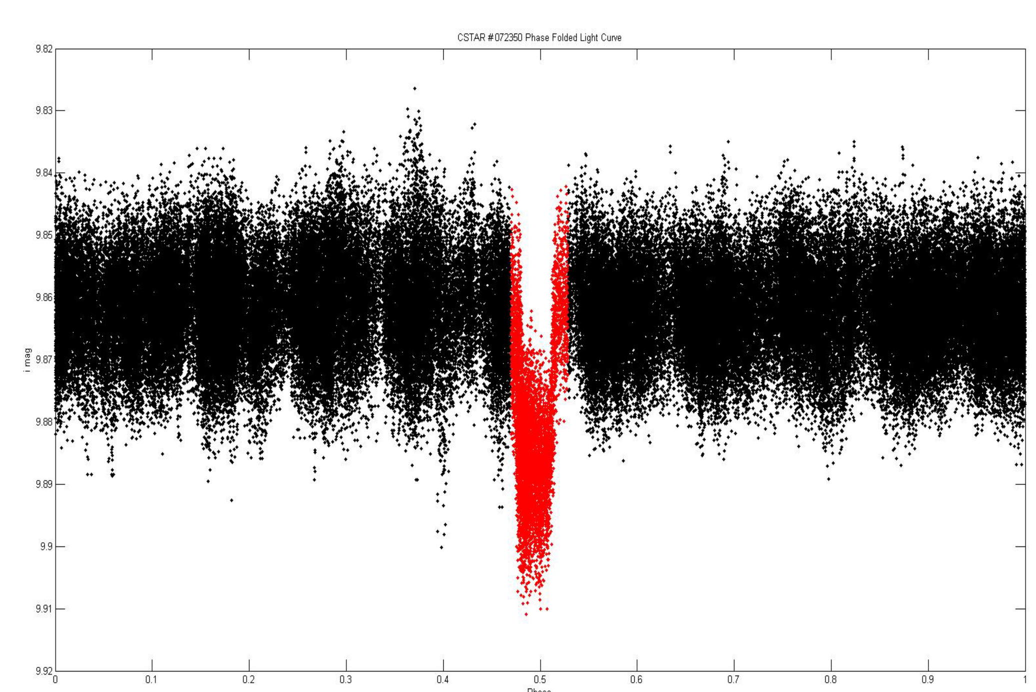
In order for the statistical testing to be accurate, we found it was important for data sets to have a large ratio between in and out of transit data. If the data contained nearly equal in transit to out of transit data, as in data typically from the Spitzer Space Telescope, significance testing using our method was impossible. The figure below demonstrates the difference between the two cases.



Left Figure: Simulated data set with in transit to out of transit ratio of 1:20. *Right Figure:* Simulated data set with in transit to out of transit ratio of 1:2. As the ratio is increased the program runs significantly better.

TRANSIT LOCATION

We wanted to confirm the transit spikes we were detecting actually occurred during the observed transit time. We simply over plotted the detected transit time data on our light curve and confirmed by visual inspection the transit we were detecting occurred during the observed transit.



Above: The figure shows the phase folded light curve of CSTAR 073250. The transit of an exoplanet is clearly visible at 0.5 phase. The red points denote the time in which our program detects a transit.

RESULTS

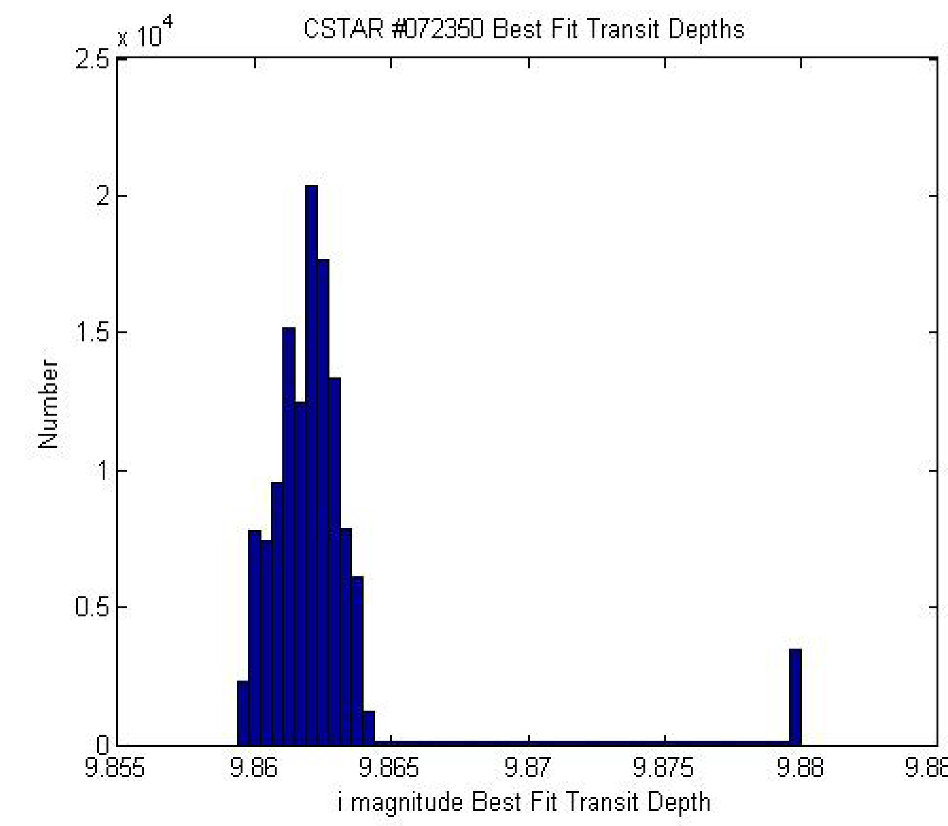
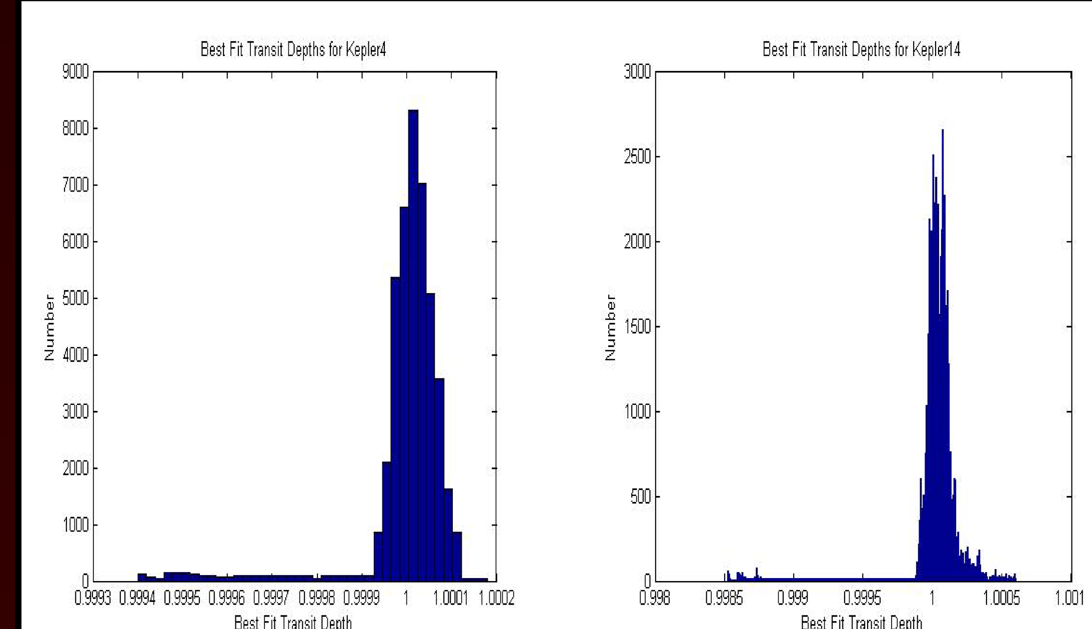


Figure: The results of running the transit fitting program for CSTAR 073250 using the light curve data obtained at Antarctica. A primary Gaussian centered at the mean magnitude is clearly visible and a secondary data spike at a depth of ~17mmag is confirmed validating the detection and the transit fitting program.



The program was also successfully run for Kepler planets such as Kepler 4 (left) and Kepler 14 (right) showing a Gaussian around 1 for the out of transit data and a secondary grouping around the expected in transit depths.

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