Searching for Transiting Planets and Eliminating False Positives in a TrES Field in Cygnus

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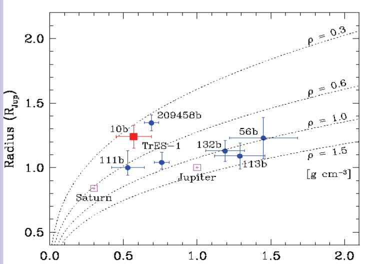

Figure 1

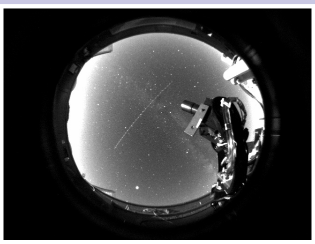

Figure 2 Sleuth as observed by Snoop, our All-Sky Camera at Palomar. More information on Sleuth and the Transatlantic Exoplanet Survey (TrES) can be found at www.astro.caltech.edu/~ftod/tres/sleuth.html. Current and archived images and movies of the Palomar night sky are available at snoop.palomar.caltech.edu.

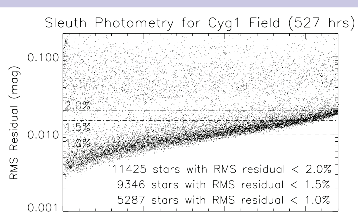

Figure 3

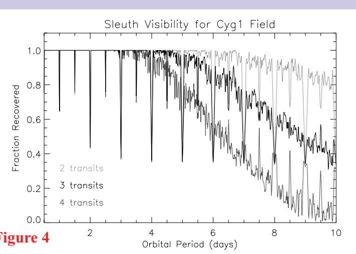

Figure 4

1. Summary

Our inability to explain the discrepancy in the radii of similar-mass transiting extra-solar giant planets (Fig.1) suggests that we do not yet understand the structure of gas giants. We should therefore attempt to find more planets that occult their host star. We present planet candidates identified with Sleuth (Fig.2), our automated 10 cm telescope (6 degree square FOV, 10" angular resolution) located at Palomar Observatory in California. We selected candidates from a new field in Cygnus at a Galactic latitude of +10 degrees. We observed this field for 70 clear nights between UT 2004 June 12 and September 1. By switching from weighted-aperture photometry to difference image analysis, we have improved our photometric precision and increased the number of stars that we can monitor for transiting Jupiters. Using 2MASS colors, proper motions and multi-epoch spectral monitoring, we tried to determine the true nature of our candidate systems, and segregate false positives from the planet candidates.

2. Identifying Candidates

We applied a difference image analysis to obtain light curves for the 17441 stars (9.5 < V < 13.0) in our field. We then decorrelated the data and averaged the 13824 field observations to 9 minute bins. The photometric precision of the resultant 3256 observations is better than 2% for 11425 stars (Fig.3).We searched the binned time series using a box-fitting algorithm for transits with periods ranging from 0.1 to 12 days. Our transit recovery rate ranges from 100% for periods less than 5 days to 40% for 10 day periods. (Fig.4). Based on the detection significance assigned to the transits and our visual examination, we identified several potential transit candidates. The phased light curves of these candidates are plotted in Fig.5. Above each plot is printed (from left to right) the candidates designation, and the period, duration, depth and SDE (detection significance) of the transit.

3. Revealing Imposters

We obtained 2MASS colors and USNO-B1.0 proper motions (Tab.1) for our candidates, and identified those whose color and proper motion are consistent with a nearby dwarf star. We obtained single-epoch spectroscopy of our candidates with the CfA Digital Speedometers and derived the effective temperature, surface gravity and rotation of these stars (Tab.1: some candidates have not yet been observed).

4. Future Observations

We intend to proceed with multi-epoch spectroscopic observations of the stars with a low rotation and a spectral type consistent with a small stellar radius to look for radial velocity variations indicative of a stellar companion. We will simultaneously perform multi-color, high angular resolution photometry on the remaining candidates. For this, we will use Sherlock, our automated 25 cm telescope with an angular resolution of 1.7". We will discern the color-dependence of the transits and possibly identify blends. Candidates with photometric and spectroscopic properties consistent with a nearby dwarf with a planetary companion will be observed using HIRES on KECK. We will measure precisely the radial velocity variations and examine the spectra for evidence of asymmetric bisector spans, an indicator of blended systems.

Name	Period (d)	Duration (h)	Depth (mag)	$J-K$[a]	μ[b] (mas/yr)	T_{eff} (K)	$\log g$	$v \sin i$ (km/s)
T-Cyg1-01076	4.67	7.85	0.010	1.146	0	–	–	–
T-Cyg1-01385	6.56	4.72	0.046	0.321	21.08	6000	3.5	16
T-Cyg1-03024	2.07	2.49	0.010	0.290	10.35	6750	4.5	35
T-Cyg1-03415	1.77	3.40	0.026	0.258	4.68	7000	4.5	65
T-Cyg1-04299	3.76	2.70	0.019	0.637	0	4750	2.5	3
T-Cyg1-04980	0.94	2.02	0.009	0.249	62.12	6750	4.5	21
T-Cyg1-06962	2.05	3.93	0.031	0.193	17.17	9500	4.0	90
T-Cyg1-07800	7.40	3.55	0.023	0.292	0	6250	4.5	22
T-Cyg1-08087	1.81	3.47	0.019	0.680	8.10	5000	2.5	9
T-Cyg1-09939	3.24	1.56	0.037	0.326	0	–	–	–
T-Cyg1-10170	2.83	3.40	0.034	0.404	0	–	–	–
T-Cyg1-11301	3.18	2.29	0.015	0.696	0	–	–	–
T-Cyg1-12974	5.45	3.92	0.045	0.242	0	6250	4.0	17
T-Cyg1-13091	4.19	3.01	0.034	0.343	0	6500	3.5	17
T-Cyg1-14777	1.45	2.09	0.016	0.334	17.59	–	–	–

[a] 2MASS infrared colors

[b] USNO-B1.0 Catalog

Table 1

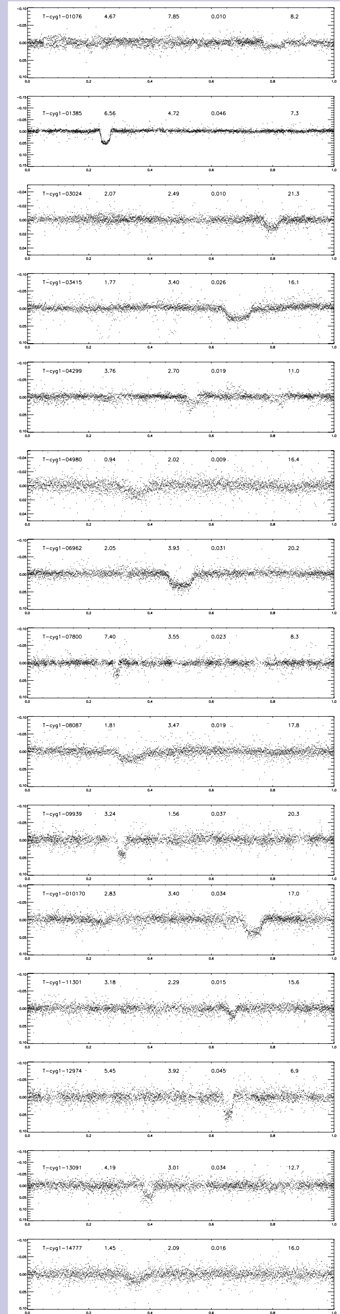

Figure 5