

Announcement of a Transitsearch.org Photometric Campaign to Check for Planetary Transits of HD 74156 and HD 37605

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draft: Nov. 30, 2004

Introduction: Over the past year, wide-field transit surveys have begun to increase the detection rate of extrasolar planets, and the discovery of objects such as TrES-1, for which the parent star is relatively bright (Alonso et al 2004), is spurring a dramatic improvement in our understanding of the properties, structure, and evolution of the shortest-period “hot-Jupiter” type planets.

The observational strategy employed by wide-field surveys makes it difficult for them to discover transiting planets with periods longer than ~ 5 days. It would be of tremendous scientific benefit, however, if a longer-period transiting planet could be detected. The discovery of a planet with an orbital period of order ~ 50 days that transits a bright parent star would yield crucial information about the structure and properties of objects that lie in the interesting temperature regime between Jupiter ($T_{eff} \sim 116K$) and planets such as TrES-1 ($T_{eff} \sim 1200K$).

Transitsearch.org’s transit detection strategy consists of coordinating multi-observer follow-up of *known* radial velocity-detected planets during the time windows in which transits are predicted to occur. This approach is a feasible and inexpensive way to locate intermediate period transiting planets, but it requires systematic campaigns and dedicated participants. Here, we describe two upcoming transit detection opportunities involving recently discovered planets orbiting HD 74156 and HD 37605. These stars (with declinations of $+5^\circ$ and $+6^\circ$, respectively) are visible worldwide, and present a 6% joint probability of displaying a transit. In order to conclusively determine whether or not transits are occurring, we require as much photometry as possible during the period between Dec. 20th 2004, and Jan. 5th 2005. Peak transit probabilities occur on Dec. 29th for HD 74156 b, and on Jan 1st for HD 37605.

HD 74156: Two planets orbiting HD 74156 were announced by the Geneva Extrasolar Planet Survey in 2001, and radial velocities for the star were later published by Naef et al. (2004). These velocities, which are available for download, contain 51 measurements made with the Elodie spectrograph and 44 measurements made with the Coralie spectrograph. Using the published Keplerian orbital elements as an initial guess, we obtained the best-fit two-planet dynamical model for the system listed in Table 1. As expected, because the

planets are dynamically well-separated, there is excellent agreement with the published fit. We estimate uncertainties in the orbital elements using a bootstrap Monte-Carlo procedure in which the velocity residuals to the best fit are sampled (with replacement) and then added back to the model radial velocity curve to create synthetic realizations of the data set. This process is repeated many times, and the variance in each orbital parameter is identified with the $1\text{-}\sigma$ uncertainty. In Figure 1, we plot the distribution of central transit times obtained as a result of applying the Monte-Carlo procedure. The most probable central transit time occurs at 20:00 on Jan 01, 2005 (UT), with a $1\text{-}\sigma$ uncertainty of 0.8 days. The total probability of transit is 3.8%, based on the orbital parameters, and the estimated $R/R_{\odot} = 1.38$ primary radius. Using the planetary models of Bodenheimer, Laughlin & Lin (2003), we estimate a planetary radius of $R_{\text{pl}}/R_{\text{JUP}} = 1.07$, which leads to an predicted central transit depth of 0.69%. A central transit should last ~ 415 minutes, which makes it very desirable to have full global latitude coverage of the event.

HD 37605: Cochran et al (2004) recently announced the first planet discovered with the Hobby Eberly telescope. This object, which orbits the metal-rich, $V=8.69$ K0V primary HD 37605, has a large orbital eccentricity ($e = 0.74$) and a 54.3 d period. Using the published radial velocities, we obtained one-planet orbital fits and uncertainties using the procedure described above. The fits are in full agreement with those found by Cochran et al (2004). Our Monte-Carlo analysis finds that the distribution of predicted transit times for HD 37605 b is wider than for HD 74156 b, because the radial velocity data set is less extensive. The most probable transit epoch occurs on Dec. 29, 2004, with a $1\text{-}\sigma$ uncertainty of 2.5 days. As shown in Figure 1, the distribution of predicted transit times is somewhat non-Gaussian, with a minor second peak in probability occurring on Jan. 3, 2005. The duration of a central transit should be approximately seven hours, and the estimated probability of transit is 2.2%. The smaller probability stems mostly from the smaller size of the primary star relative to HD 74156. The smaller parent star leads to a larger predicted transit depth, namely 1.8%, similar to that observed for HD 20945 b.

We urge observers to obtain as much baseline photometry for these stars as possible prior to the end-of-the-year transit windows. Anyone who observes a transit or contributes substantial coverage of the transit windows will be included in any publishing of campaign results. Further observing information will be posted on www.transitsearch.org, and at www.aavso.org.

Photometry: Since millimag precision is needed during this campaign some observers may need to observe without a filter. Both of these stars have a $B-V < 1$ so unfiltered photometry is acceptable. However, in order to facilitate combing observations of many different observers we request that a V filter be used where possible. Test your observing strategies ahead of time to find the optimal exposure time, filter setting and reduction methods. High time resolution is not needed since the transit windows are so long, so feel free to combine images for better SNR. Charts with comparison and check stars are in production and will be published soon at <http://www.aavso.org/news/transits.shtml> .

Reporting Observations: Please report your observations to the AAVSO. If you do not have an AAVSO observer code visit <http://www.aavso.org/observing/submit/apply.shtml>

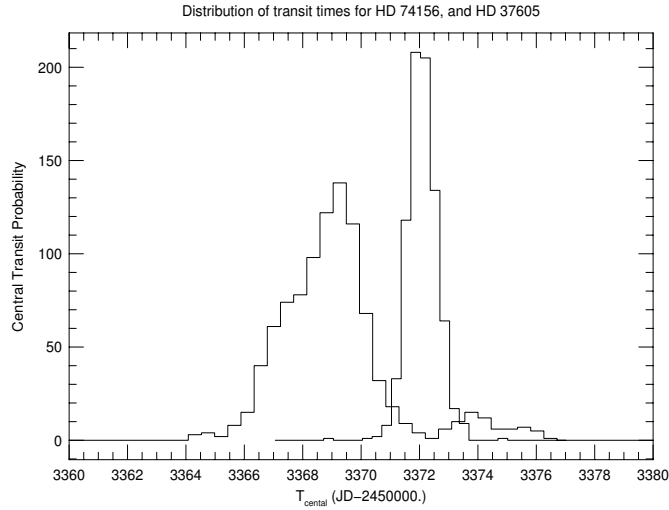


Figure 1: Histogram showing central transit times computed using self-consistent orbital fits to published radial velocity data, combined with a bootstrap Monte-Carlo method to compute transit times. The peak probability for observing a transit by HD 74156 b occurs at 20:00 on Jan 01, 2005 (UT), while the peak probability for observing a transit by HD 37605 occurs at 17:00 on Dec 29, 2004 (UT). The uncertainties in the orbital solutions for both objects lead to a range of several days in the possible transit times, with the distribution of T_c for HD 37605 being somewhat wider. Continuous coverage during the transit windows is therefore required in order to definitively confirm or rule out the presence of transits.

to apply for one. The AAVSO has an online system called WebObs that makes it easy to submit your observations in a variety of formats. Send any questions about formats and procedures to aaronpaavso.org. The AAVSO will process and combine the observations. In addition, they will keep light curves updated throughout the observing campaign at <http://www.aavso.org/news/transits.shtml>.

Table 1: Stellar and Planetary Properties of HD 74156 b and HD 37605 b

Parameter	HD 74156 b	HD 37605 b
Orbital Period	51.642 ± 0.016 d	54.29 ± 0.36 d
Mean Anomaly at Epoch	$208.^\circ \pm 3.^\circ$	$56.^\circ \pm 4.^\circ$
eccentricity	0.638 ± 0.02	0.74 ± 0.01
inclination (assumed)	90.0°	90.0°
ϖ	$181.7^\circ \pm 2.3^\circ$	$211.2^\circ \pm 1.8^\circ$
Planet Mass	$1.86 M_{\text{JUP}}$	$2.87 \pm 0.08 M_{\text{JUP}}$
Transit Probability	3.8%	2.2%
Planetary Radius	$1.07 R_{\text{JUP}}$	$1.09 R_{\text{JUP}}$
Transit Epoch	JD 2453372.35 \pm 0.8	JD 2453369.22 \pm 2.5
Predicted Transit Depth	0.69%	1.78%
Predicted Transit Duration	415 min.	435 min.
Right Ascension	08 42	05 40
Declination	+04 35	+06 03
Vmag	7.62	8.69

References

Alonso, R. et al. 2004, “TrES-1: The Transiting Planet of a Bright K0V Star”, *Astrophysical Journal Letters* In Press astro-ph/0408421.

Bodenheimer, P., Laughlin, G., & Lin, D. N. C. 2003, *Astrophysical Journal*, **592**, 555.

Cochran, W., Endl, M., McArthur, B., Paulson, D., Smith, V., MacQueen, P., Tull, R., Good, J., Booth, J., Shetrone, M., Roman, B., Odewahn, S., Deglman, F., Graves, M., Soukup, M., & Villarreal, M. L., Jr. 2004, *Astrophysical Journal Letters*, **611**, L133.

Naef, D., Mayor, M., Beusit, J.-L., Perrier, C., Queloz, D., Udry, S., & Sivan, J.-P. 2004, *Astronomy and Astrophysics*, **414**, 35.