Young Exo-Planet Transit Initiative (YETI)

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Abstract

It is still not clear whether massive gas giant planets form by disk instability or by core accretion; or whether both paths are possible. We search for transiting planets around stars younger than 10 Myr in star forming regions and clusters using several telescopes around the world. We plan to measure radii and mean densities of young planets with the transit technique. Among the 311 transiting planets known so far [1], none are younger than a few hundred Myr. Recently a transiting candidate in the ~8 Myr old cluster 25 Ori was reported [2].
We found in the data of the first two target cluster already three transiting candidates, we present here the observations and follow ups. We also work on other kinds of variability, such as young eclipsing binaries, rotation and pulsation periods, flares, and all other kinds of variability.

Clusters and Telescopes

We decide on possible YETI clusters in the following way: They should be best visible with most of the YETI telescopes, considering the typical 1 deg² field, contain many of member stars of the right brightness, are less than 800 pc away and are not investigated with better telescopes. The monitoring started on the 4 Myr old cluster Trumpler 37 (Tab. 1) which was observed in summers 2009 to 2011. The observation of 25 Ori were performed in the winters 2009/10 till 2012/13. In 2012 the monitoring of further clusters were started: IC 348, Col 69. Recently we started observation of NGC 1980 and NGC 7243.

Cluster name	Age [Myr]	Distance [pc]	Number of stars with R < 16.5 mag			Expected number of transiting planets	
			members in total	members in FoV	stars in FoV	in FoV	among members
Trumpler 37	4	870	614	≥ 469	6762	8.1 ± 2.8	≥ 1.1 ± 1.1
25 Ori	7-10	323	179	≥ 108	1045	1.3	≥ 0.3
total			793	> 577	>7807	>9.4 ± 4	> 1.4 ± 14

Tab. 1: Sample of the target clusters [3]

YETI consist of a network of telescopes with mirror diameters of 40 cm to 2.3 m. The telescopes are located in eastern Asia, central Asia, Europe, North and South America (Fig. 1), hence for northern targets continuous observation are possible.
To get enough data to cover all phases of periods of several days, each cluster is observed during three years. In each year three YETI campaign runs of length one to two weeks are performed on each cluster. During one run, typically 60-90 h of observational data are obtained.

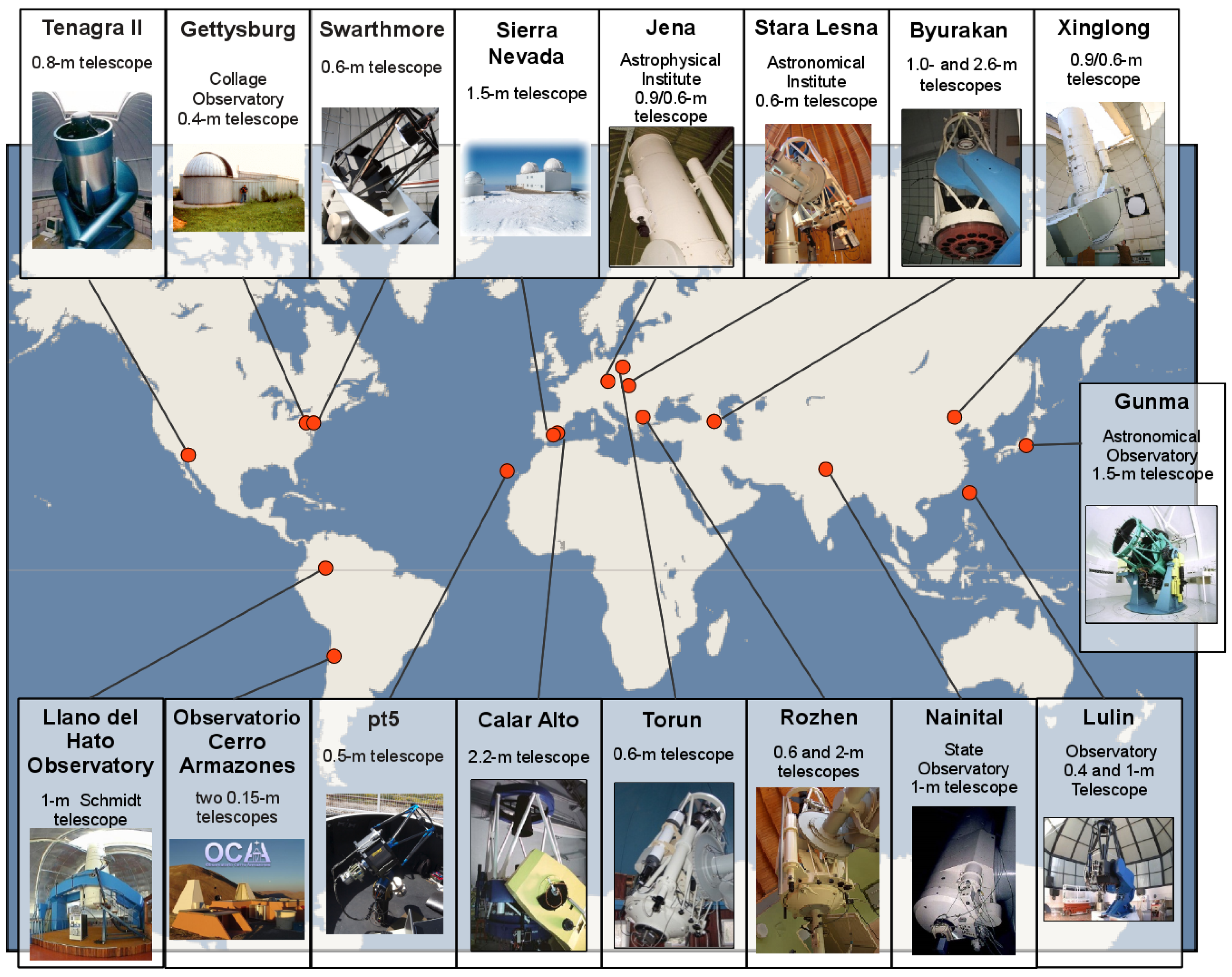

Fig. 1: The YETI network telescopes.

Variable stars

We found a lot of variable stars in the data (e.g. more than 350 in Trumpler 37), two examples are shown in Fig. 8 and 9.

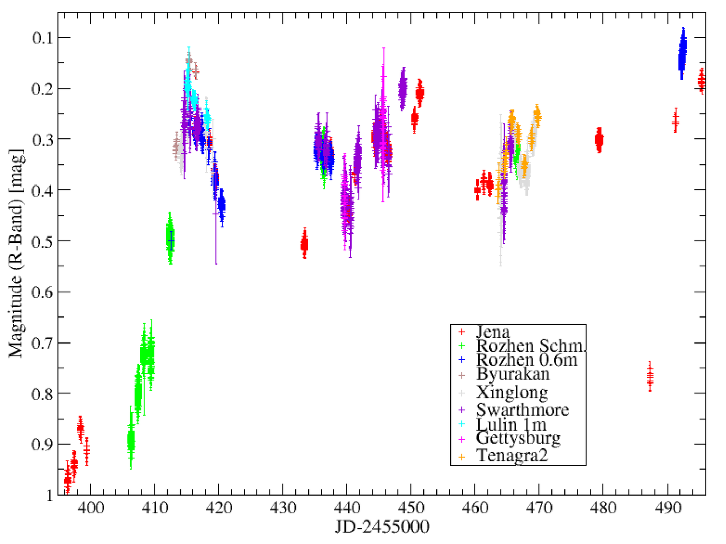

Fig. 8: Flare star GM Cep (member in Trumpler 37) during the YETI campaign runs in 2010. With YETI it is possible to follow the brightness changes without big gaps. See also [4] for YETI data on GM Cep.

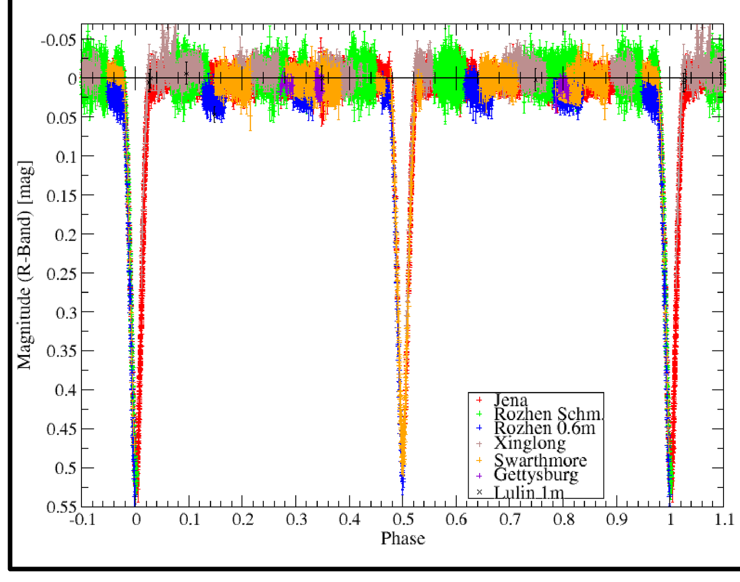

Fig. 9: Light curves of an eclipsing binary in the field of Trumpler 37. The Period is nearly 6 days, causing gaps in the phase folded lightcurve, if only one telescope is used. With YETI the phase folded light curve is complete.

Transit candidate in 25 Ori

A transit around a weak line T Tauri star was found in 25 Ori by the PTF Orion Project [2] which is also visible in our data.
They PTF Orion Project observed two sets of light curves in the years 2009 and 2010. It can be seen that there is an overall change in the transit shape between the two years data sets. Explanations for this remain speculative and can only be investigated by further photometric follow-up observations.
The phase folded light curve from the Jena telescope is shown in Fig. 3. Due to the T Tauri host star and hence variable with an amplitude of 0.17 mag in timescales similar to the orbital period of the planet, shown in Fig. 2.
We did high resolution imaging in J, H an Ks and could reject the hypothesis of eclipsing background stars, only one faint source is is visible in the FoV. Further investigations on that object are planed.
[2] took optical high resolution spectra to solve the radial velocity orbit. Due to stellar activity the data points are scattered more than expected by the instrumental errors. They did several fits, the best fitting eccentric orbit with zero phase and period as in the photometric data puts the planet in the stars atmosphere, while a circular fit gives only reasonable results when the phase is free floating and offset by a quarter of the phase of the photometric orbit. Hence the activity allowed to derive only an upper limit for the mass of 5.5 M_{Jup} [2].

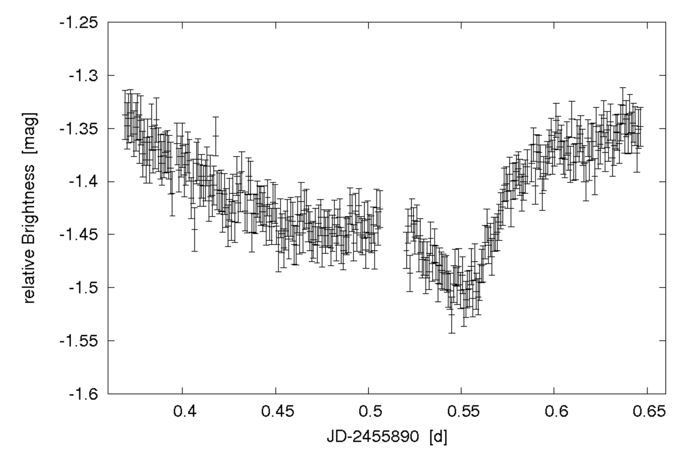

Fig. 2: Light curve of a single night for the transit candidate in 25 Ori (Jena data). The stellar variability is seen over the whole night and the transit occurs at JD=0.55 d.

R [mag]	15.2
EW(Li) [Å]	0.40
P [d]	0.45
ΔR [mmag]	38
R_P/R_*	0.18
M_P [M_{Jup}]	<5.5

Tab. 2: Properties of the transiting candidate in 25 Ori [2].

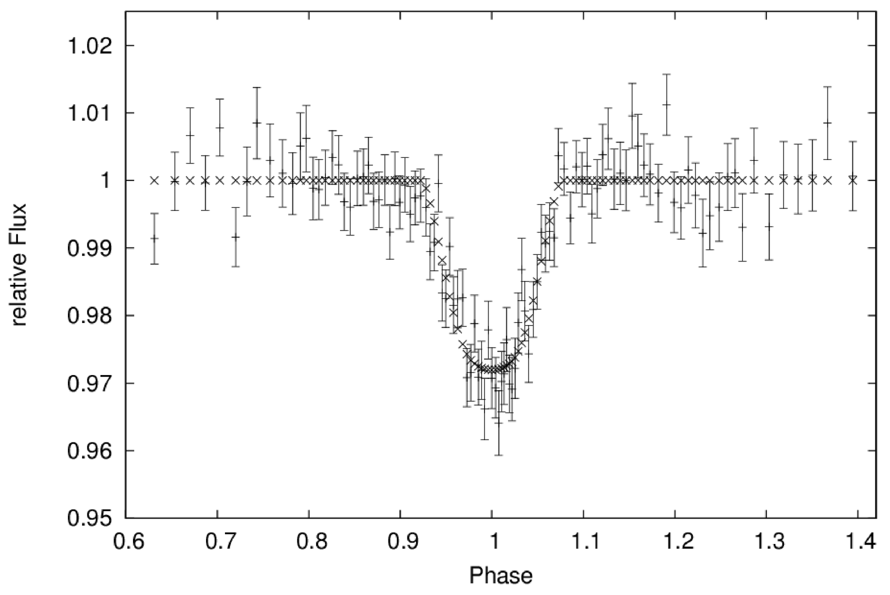

Fig. 3: Phase folded and binned Jena data of 11 transits. The stellar variations were removed before.

Transit candidates in Trumpler 37 (see also Poster 2K042)

Two transiting candidates were already found in the Trumpler 37 data. Fig. 4 shows the light curve of several YETI telescopes for the first candidate and the light curve for the second candidate is shown in Fig. 5 (only Jena data). The second candidate shows additional activity of few mmag in timescales of ~9d.
For the first candidate all follow ups are already done, while the second candidate needs further investigations.
For both stars high resolution imaging was done using IRCS at the Subaru telescope to check for possibly eclipsing background sources in the YETI point spread functions (minimum FWHM=2.5"). All sources around the first candidate are too faint to cause the dip in the brightness, but next to the second candidate is a bright source (Fig. 6).
For the first candidate high resolution spectra were obtained to measure the radial velocity orbit. The resulting fit is shown in Fig. 7. The amplitude of the signal yields to a companion mass consistent with that of a M5 to M6 dwarf, hence it is a false positive.
For both stars low resolution spectra were obtained to check for Lithium absorption as an indicator for youth of the star. In both cases only small amount of Li was measured, indicating that the candidates are not members in the young cluster.
Table 3 gives the parameters for both transiting candidates.

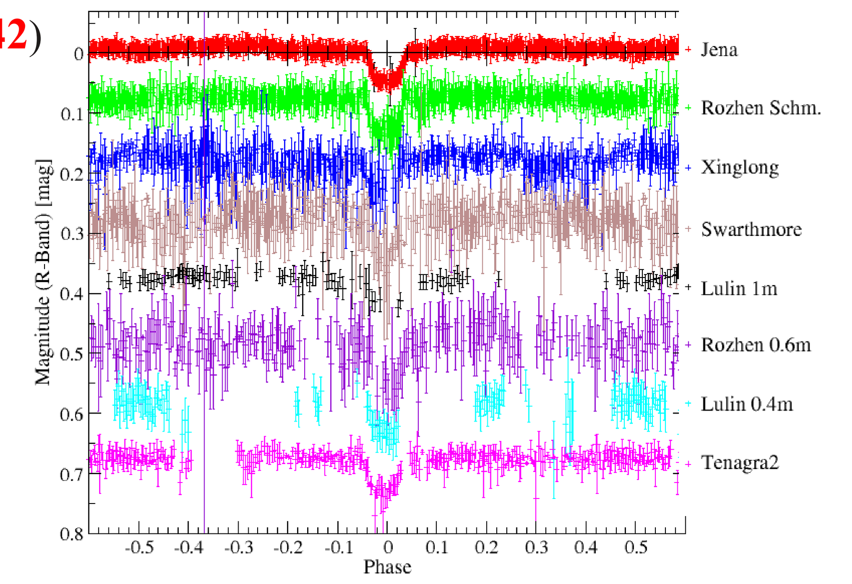

Fig. 4: Phase folded and binned lightcurves of the first candidate for some YETI telescopes. Jena observed the most data, hence the binned light curves remains the smallest scatter.

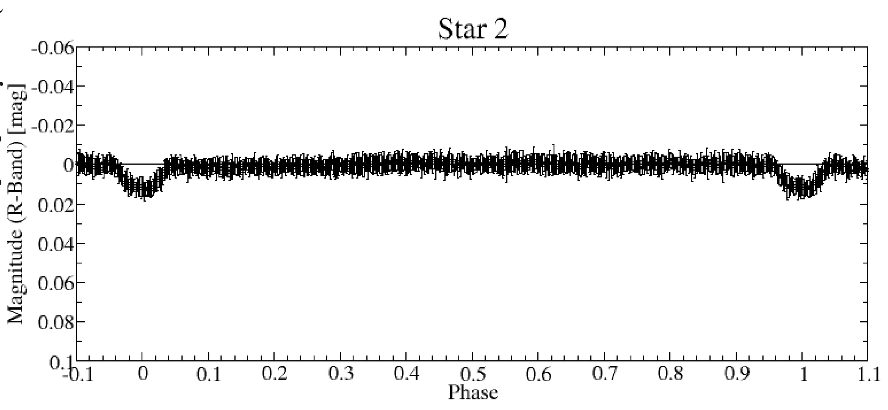

Fig. 5: Phase folded and binned light curves of the second transiting candidate found in Trumpler 37 cluster (Jena data). The variation due to activity was subtracted before binning. No secondary eclipse is visible.

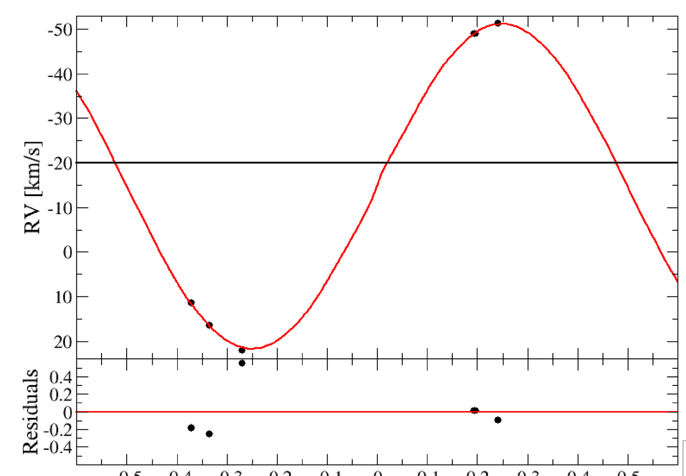

Fig. 7: Radial velocity curve of the first candidate. The circular fit was done using the photometric period and zero phase

Star:	1	2
R [mag]	15.1	13.4
SpT	F8 - G5	G2 - G4
EW(Li) [Å]	<0.1	<0.05
P [d]	1.36	0.74
ΔR [mmag]	45	15
R_P/R_*	0.20	0.11
M_P [M_{Jup}]	200	not observed so far

Tab. 2: Properties of the transiting candidates in Trumpler 37.

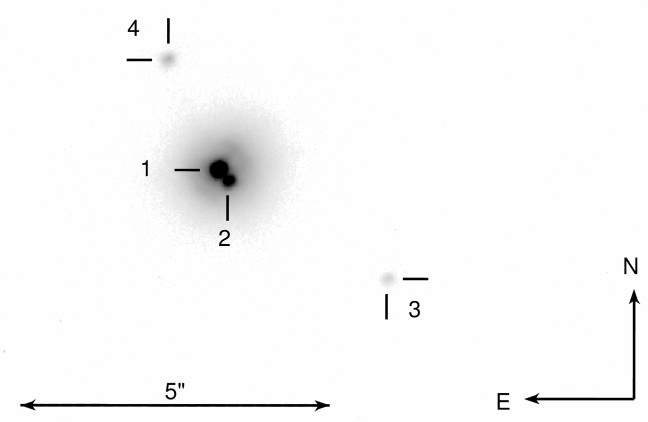

Fig. 6: Subaru IRCS image of the second candidate. Source 2 could cause the dip if its an eclipsing background star, hence further observation are needed.

Discussion and Outlook

Small telescopes such as the one near Jena (1m) and others that form the YETI network enable us to detect transits of extrasolar planets. With the wide distribution in geographic longitude of our network nodes we can observe nearly continuously in order not to miss any transits, and also to find planets with periods close to a multiple of one day. Young clusters including Trumpler 37, 25 Ori, IC 348, Col 69, NGC 1980, and NGC 7243 are searched for transits by YETI for several weeks.
For our first candidates in Trumpler 37 and 25 Ori we partially did the follow-up observations to reject false positives and measure the mass of the companion. The first candidate in Trumpler 37 turned out to be a low mass star rather than a planet. Further follow-up observations are in progress.
We expect further candidates among the cluster members from our ongoing observations as we reduce more data and work in a improved transit search, using a Bayesian approach for detecting points at which there are changes in the light curve. At these points we fit a synthetic transit model (Mandel & Agol [5]) to establish whether the changes are due to a true transit event.
Confirmed cases of young transiting planets will enable us to test models of planet formation and evolution.

References

[1] Schneider, J., www.exoplanet.eu
[2] van Eyken, J. C., Ciardi, D. R., von Braun, K., et al., 2012, ApJ, 755, 42
[3] Neuhäuser, R., Errmann, R., et al. 2011, AN 332, 547
[4] Chen W.-P., A., Hu, S. C.-L., Errmann, R., et al. 2012: ApJ 751, 118
[5] Mandel, K., & Agol, E. 2002, ApJ, 580, L171