YETI - Search for young transiting Planets in Trumpler 37

R. Errmann[1], R. Neuhäuser[1], G. Torres[2], A. Kellerer[3], M. Kitze[1], St. Raetz[1], M. Seeliger[1] , D. Dimitrov[4], D. Kjurkchieva[5] and YETI Observers all over the world

[1] Astrophysikalisches Institut und Universitäts-Sternwarte Jena, Schillergäßchen 2-3, 07745 Jena, Germany; ronny.errmann@uni-jena.de
[2] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street Cambridge, MA 02138, U.S.A.
[3] Centre for Advanced Instrumentation, Dept of Physics, South Road, Durham DH1 3LE, UK
[4] Institute of Astronomy and NAO, Bulg. Acad. Sc., 72 Tsarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria
[5] Shumen University, 115 Universitetska str., 9700 Shumen, Bulgaria

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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. 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 search for transiting planets around stars younger than 10 Myr in star forming regions and clusters using several telescopes around the world (YETI network, Young Exoplanet Transit Initiative), in order not to miss any transit event. We plan to measure radii and mean densities of young planets with the transit technique. We already found three first candidates, including the one reported in [2]. For one them, the follow-up observations revealed a false positive. For the others follow-up observations are partially done and further are planed. We also expect some more candidates in the data.
Here we present some of the results of the first YETI cluster: Trumpler 37. For more information about YETI and the other target clusters please see Poster **2K047**.

Fig. 1: The YETI network telescopes.

Observations

- Campaign: 6 runs in summers 2010 and 2011 (each year 3 runs): ~27000 images per year
- Additional observation with the Jena Schmidt telescope (STK):
  - 160 nights in 2009 – 2011 result in 25800 good quality data points
  - photometric precision over single nights: below 5 mmag standard deviation for 850 stars, better than 30 mmag for 5500 (Fig. 2) → covering stars $R \leq 16.5$ mag, corresponding to K7 in Trumpler 37
- Observation mostly in the R filter, alternating long and short exposure time; mosaicing, if field of view is small

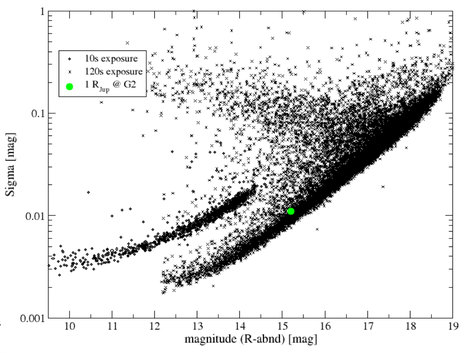

Fig. 2: Photometric precision for the Jena STK. For the brightest stars a standard deviation of less than 5 mmag in the light curve is reached in a single night. For 5500 stars it is better than 30 mmag, so detection of Jupiter size planets around G and K stars in distance of Trumpler 37 is well possible.

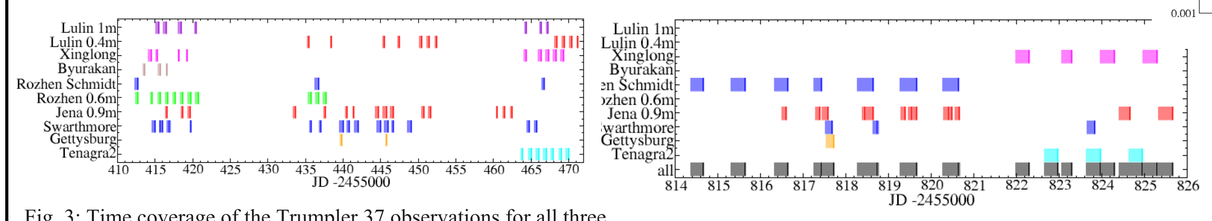

Fig. 3: Time coverage of the Trumpler 37 observations for all three YETI runs in summer 2010 (left) and the last YETI run in summer 2011 (right). In the later run, only a small gap occurs during 48h observation. Note that not all telescopes could always participate and that bad weather caused observational gaps.

Variable stars in Trumpler 37

More than 350 variable stars were found so far:

- many T Tauri stars (some already known [4]-[7])
- rotating and pulsating stars (Periods 1h < P < ≈300d)
- irregular variabilities
- 50 eclipsing binaries
- 30 Flares
- 2 transit candidates so far (further candidates expected: data reduction is still incomplete, and we plan to co-add images to go deeper)

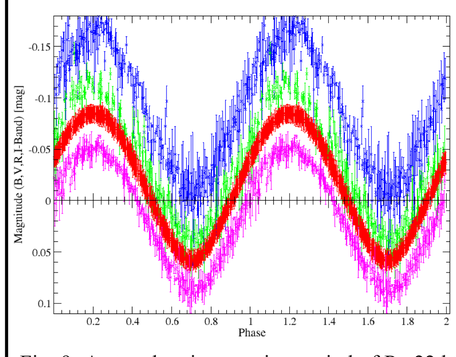

Fig. 9: A star showing rotation period of P=.22d for the filters B,V,R, and I (up to down and color coded, only Jena data). A slight phase shift between R and I is visible.

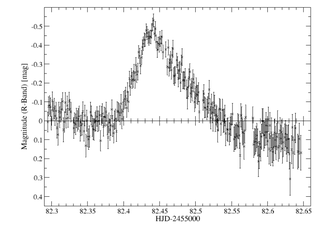

Fig. 10: A flare occurring on a variable star. The amplitude of the flare is R=0.5 mag. The star shows sinusoidal variations with period of 0.87 d and semi-amplitude of 0.15 mag.

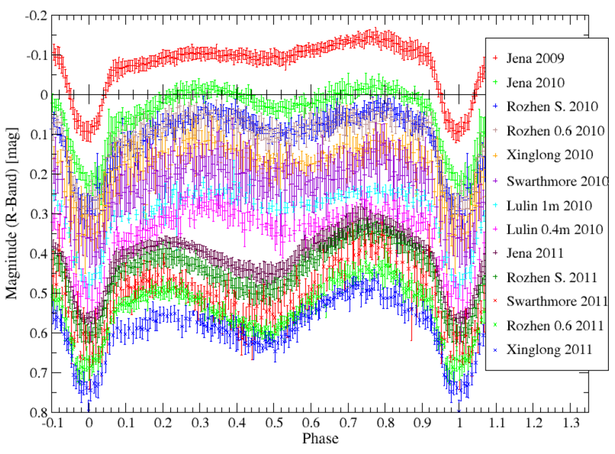

Fig. 11: Phase folded and binned lightcurves of a eclipsing binary with P=0.38d. The data from the YETI telescopes is grouped for the different years. Between 2009 and 2011 strong variations are visible in the light curve.

Transit search and candidates in Trumpler 37

Transit search was done on the partly reduced data set, fitting a box-shaped model to the light curves of single nights. We found two transiting candidates with this method (Fig. 4, Tab. 1).
A new algorithm is being tested 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 [9]) to establish whether the changes are due to a true transit event.
We expect to find more candidates by applying this algorithm to the full data set.

Tab. 1: Properties of the transiting candidates and host stars in Trumpler 37.

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

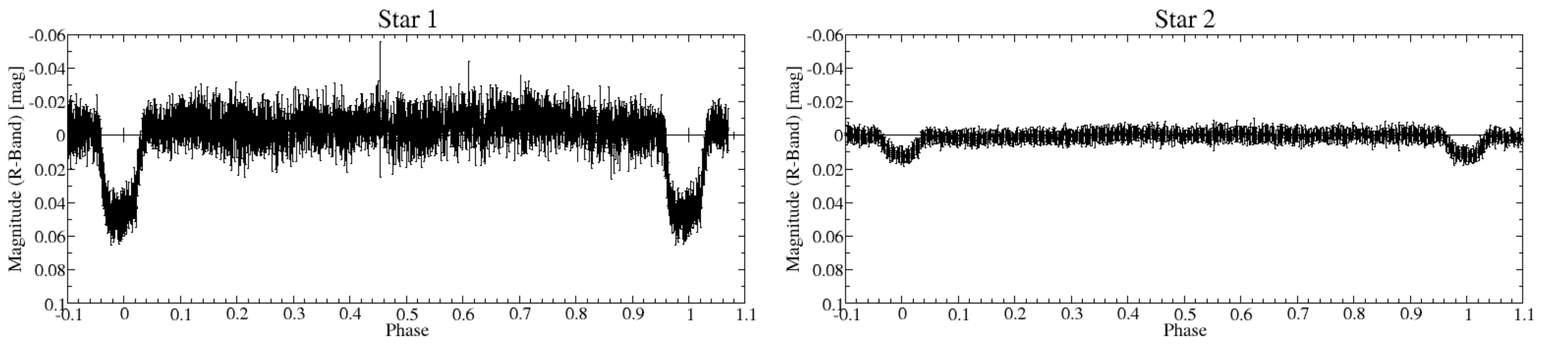

Fig. 4: Phase folded and binned light curves of the two transiting candidates found in Trumpler 37 cluster (Jena STK data). The second candidate shows additional variation in the light curve due to activity, these variations were subtracted before binning.

First candidate

For the **first candidate** all follow-up observations were done:

- high quality light curve of transit with Calar Alto 2.2 m telescope
- low resolution spectra with Calar Alto 2.2 m telescope
- high resolution imaging with Subaru 8 m telescope, using adaptive optics (Fig. 6)
- high resolution spectra with 10 m Keck telescope

In the low resolution spectra only small Lithium absorption line was detectable, so youth was dubious.
With the high resolution image, eclipsing background stars in the YETI PSF (minimum FWHM=2.5") could be rejected, because all objects found in a distance 0.15"-3" next to the main source are too faint to produce the measured brightness change.

The radial velocities (Fig. 7) were measured from the high resolution spectra. The orbit was fitted simultaneously with the photometric data using PHOEBE. The circular fit with period and phase fixed to the values from photometric data results in a semi-amplitude of 36 km/s, meaning the companion mass is about $0.21 M_{sun}$. Therefore, the companion is probably a M5 or M6 dwarf, hence a false positive.

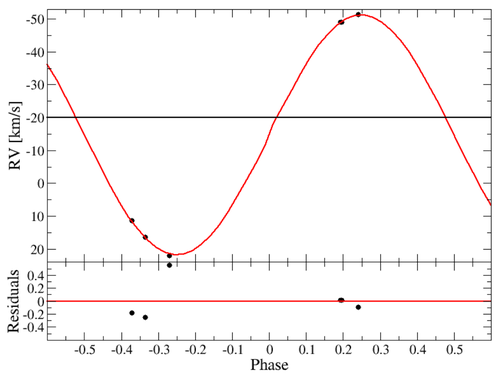

Fig. 7: Radial velocity curve of the first candidate

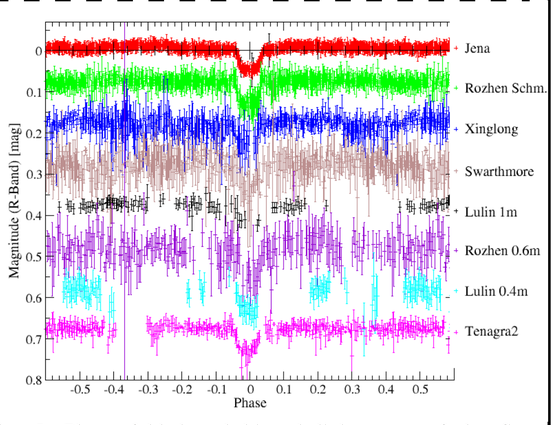

Fig. 5: Phase folded and binned lightcurves of the first candidate for some YETI telescopes. Jena observed the most data, hence the binned light curve of that telescopes remains the smallest scatter.

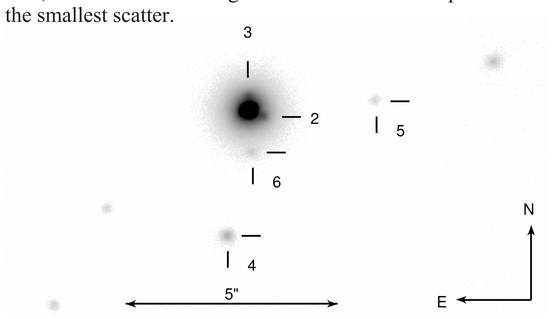

Fig. 6: Subaru IRCS image of the first candidate. The sources next to the star are too faint to cause the transit like signal

Second candidate

The host star of the **second candidate** is slightly active, as expected for a young star. The brightness changes in timescale of ~9 days by about 15 mmag, without showing strict periodicity. These brightness changes were removed for the phase folded data (Fig. 4). The low resolution spectra taken with Calar Alto 2.2 m telescope show no significant Lithium absorption, hence youth is dubious.
In the high resolution Subaru IRCS image (Fig. 8) a bright star next to the main source is visible. Therefore we have to rule out the existence of a blended eclipsing binary with further observation.

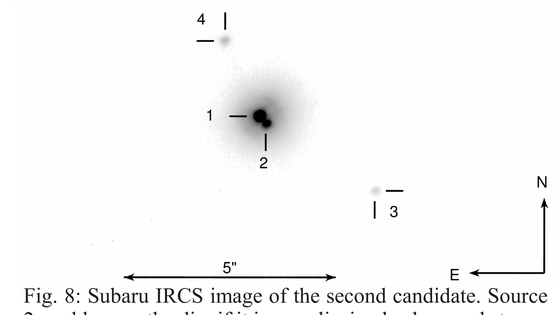

Fig. 8: Subaru IRCS image of the second candidate. Source 2 could cause the dip, if it is an eclipsing background star.

Discussion and Outlook

Small telescopes such as the one near Jena 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. Each of the 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 candidate in Trumpler 37 we have completed follow-up observations to reject false positives and measure the mass of the companion, which turned out to be a low mass star rather than a planet. Follow-up observations for a second candidate are in progress. We expect further candidates among the cluster members from our ongoing observations on the different clusters, from further data reduction and from an improved transit search algorithm. Confirmed cases of young transiting planets will enable us to test models of planet formation and evolution.

References

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