A search for transit timing variation

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Photometric follow-ups of transiting exoplanets (TEPs) may lead to discoveries of additional, less massive bodies in extrasolar systems. This is possible by detecting and then analysing variations in transit timing of transiting exoplanets (TTV). In 2009 we launched an international observing campaign which aim is to detect and characterise TTV signals in selected transiting exoplanets. The programme is realised by collecting data from 0.6–2.2-m telescopes spread worldwide at different longitudes. We present our observing strategy and summarise first results for a selected TEP: we show the preliminary TTV signal in WASP-3b with evidence for a 15 Earth-mass perturber in an outer 2:1 orbital resonance.

1. OUR STRATEGY

Selecting
the most promising targets

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Reconnaissance campaign
attempt to detect TTV with small telescopes (<1 m)

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Preliminary hypothesis
models reproducing observed variations of timing residuals identified by three-body simulations

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Follow-up campaign
• photometric follow-up with big telescopes (>1 m) to verify and characterise TTV signal
• spectroscopic follow-up to get more precise radial velocity measurements

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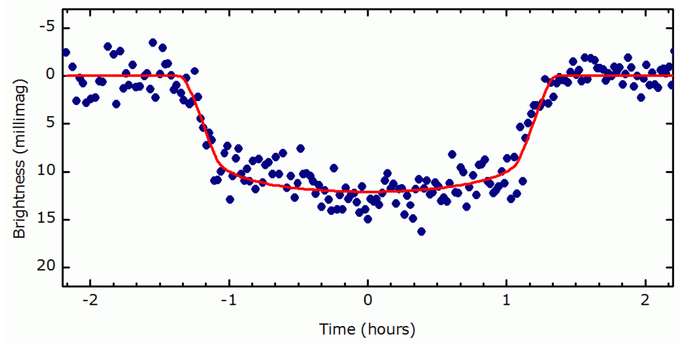
Final thesis
model(s) with third body, based on high-precision photometric and spectroscopic data sets

2. OBSERVATIONS

Red dots mark astronomical observatories engaged in our campaigns. Data from telescopes located at various longitudes are needed to cover many transits of a given target during observing season.
We are open for cooperation.

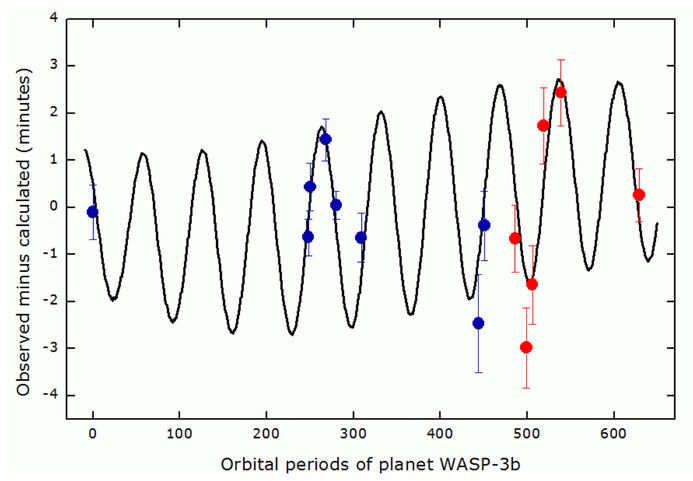
3. WASP-3b – FIRST RESULTS

In 2009 and 2010 we observed 6 transits of exoplanet WASP-3b during the dedicated transit-timing-variation campaign. The team used the 90-cm telescope of the University Observatory Jena (Germany) and the 60-cm telescope of the Rohzen National Astronomical Observatory (Bulgaria).



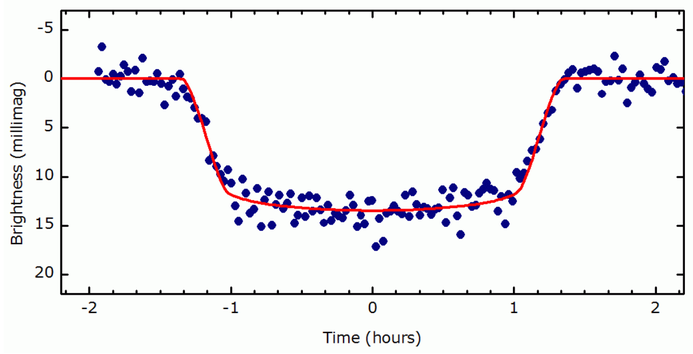
The variation in *R*-band light caused by the transit of the planet WASP-3b. Data originate from observations made on 18 April 2010 with the University Observatory Jena 90-cm telescope. Individual data points are shown as dots. The brightness of the star in millimagnitudes is plotted against observing time in hours (0.0 marks the centre of the transit). The red line is our best fit to the data. The precision of 1.2 mmag was achieved due to telescope defocusing.

We noted that the observed transit timing cannot be explained by a constant period but by a periodic variation in the observations minus calculations diagram. Simplified models assuming the existence of a perturbing planet in the system and reproducing the observed variations of timing residuals were identified by three-body simulations. We found that the configuration with the hypothetical second planet of the mass of about 15 Earth masses, located close to the outer 2:1 mean motion resonance is the most likely scenario reproducing observed transit timing. We emphasize, however, that more observations are required to constrain better the parameters of the hypothetical second planet in WASP-3 system (Maciejewski et al. 2010, arXiv/1006.1348).



This is the so-called O-C diagram for WASP-3b. We plot the difference between observed (O) transit time and calculated (C) expected transit time on the y-axis in minutes versus the time given as orbital periods of WASP-3b. We plot the previously published transit times as blue dots and our own new measurements as red dots. If there was only one planet around the star WASP-3, then all points should be on one straight line.

In summer 2010 the dedicated follow-up campaign has begun. New radial-velocity measurements have been gathered with the Hobby-Eberly Telescope in Texas (USA). High-precision light curves have been obtained with 2-m class telescopes in Europe, North America and Asia. The research is still ongoing.



An *R*-band light curve of the complete transit observed on 23 July 2010 with the 2.2-m telescope at Calar Alto (Spain). Timing error is 25 s and photometric precision is 0.9 mmag despite non-photometric atmospheric conditions.