From Interacting Binaries to Exoplanets: Essential Modeling Tools
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New Photometric Observations of the Transiting Extrasolar Planet TrES-3b

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Abstract. We present new transit observations of the transiting exoplanet TrES-3b obtained in the range 2009 – 2011 at several observatories. The orbital parameters of the system were redetermined and the new linear ephemeris was calculated. We performed numerical simulations for studying the long-term stability of orbits.

Keywords. exoplanets, fundamental parameters, individual (TrES-3b)

1. Introduction

TrES-3b is one of the more massive transiting extrasolar planets. The planetary system consists of a nearby G-type dwarf and a massive hot Jupiter with an orbital period of 1.3 days. It was discovered by O'Donovan *et al.* (2007) and a discovery-quality light curve has also been obtained by the SuperWASP survey (Collier Cameron *et al.* 2007). Follow-up transit photometry has been presented by Sozzetti *et al.* (2009) and Gibson *et al.* (2009).

2. Observations & Results

All observations used in this study were carried out at several observatories: Stará Lesná (Slovakia), Toruń Center for Astronomy (Poland), Michael Adrian Observatory (Germany), University Observatory Jena (Germany) and Vihorlat Observatory (Slovakia). We used telescopes with diameters of the primary mirrors in the range of 30–120 cm and optical CCD-cameras (RI-bands). In order to have a homogeneous dataset we have used the composition of 560 data points from two nights obtained at one observatory with the same filter (see Fig. 1). To obtain an analytical transit LC, we assumed the quadratic limb darkening law. The limb darkening coefficients c_1 and c_2 were linearly interpolated from Claret (2000) for the following stellar parameters: $T_{\rm eff} = 5650$ K, *log* (g) = 4.4 and [Fe/H] = -0.19 (based on the results of Sozzetti *et al.* 2009). Finally, the orbital parameters of the system were redetermined: $R_p/R_* = 0.1819(20)$,

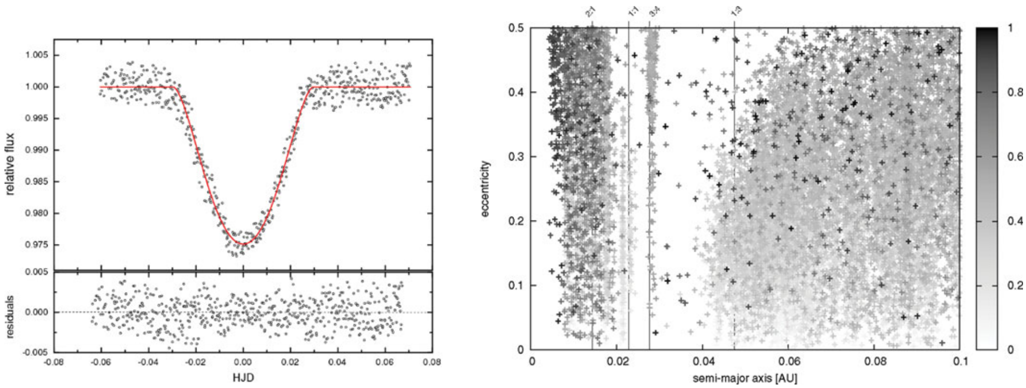

Figure 1. Left Composition of 560 data points from the two nights: 13/07/10 and 20/08/10 (dd/mm/yy) obtained at Michael Adrian Observatory in Trebur (Germany). **Right** Stability plot in the $a - e$ plane showing the maximum eccentricity.

$R_*/a = 0.1785(70)$, $i = 80.9(7)$, $R_* = 0.876^{+0.008}_{-0.016}\ R_\odot$ and $R_p = 1.551^{+0.014}_{-0.028}\ R_J$. To estimate the uncertainties of parameters, we have used the Monte Carlo simulation method. Based on the transits obtained at other observatories, we calculated the following new linear ephemeris for TrES-3b: $T_c(E) = 2454538.5807(1) + \mathrm{E} \times 1.30618595(15)$.

In this part of our work, we investigated the gravitational influence of TrES-3b on a potential second planet in the system. Gibson *et al.* (2009) claimed, that their data are sensitive enough to probe small mass planets on circular orbits near the 2:1 mean-motion resonance (MMR) with TrES-3b. We performed numerical simulations for studying the stability of orbits and checking their chaotic behavior using the method of maximum eccentricity (e.g. Dvorak *et al.* 2003). We have generated 10^5 massless particles to represent small planets (Earth-like) in this system. The long-term stability plot in the $a - e$ plane with the maximum eccentricity after 500 years (about 140 000 revolutions of TrES-3b around the parent star) is shown in Fig. 1 (right plot). We found that the region from 0.02 AU to 0.04 AU is almost completely depleted, except the regions near 1:1 and 3:4 MMRs. The region near 2:1 MMR is richly populated, but the particles have relatively high eccentricities and inclinations, thus the stability and also the detection using the TTV method is questionable. More stable regions are beyond the 1:3 MMR, where the gravitational influence of the TrES-3b is weak. A more detailed study of the long-term stability in this system (especially near 2:1 MMR) will be presented in future work.

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