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Short-period Kepler exoplanet candidates: search for a circum-planetary material

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Abstract. This article deals with a sample of 20 short-period exoplanet candidates with a period similar to KIC012557548b from the Kepler mission. KIC012557548b is an exoplanet candidate which shows a variable and asymmetric transit. It is most probably due to a comet-like tail emerging from the exoplanet. Our main aim is to search for comet-like tails similar to KIC012557548b, or another form of circum-planetary material.

Key words: Stars: planetary systems – techniques: photometric

1. Introduction and data analysis

A unique close-in Mercury-size Kepler exoplanet candidate KIC012557548b has been discovered recently by Rappaport *et al.* (2012). This object is a transiting disintegrating exoplanet with a comet-like tail and has an extremely short orbital period of 0.65356(1) days. The host star that is apparently being occulted is KIC012557548, a V = 16 magnitude K-dwarf with $T_{eff} \simeq 4400$ K (Rappaport *et al.*, 2012). Another close-in Kepler exoplanet candidate KIC8639908b ($R_p \leq 1.06 R_\oplus$), detected recently also by Rappaport *et al.* (2013) with an orbital period of 0.91 days, exhibits a distinctly asymmetric transit profile, likely indicative of the emission of dusty effluents, and reminiscent of KIC012557548b. Close-in exoplanets, like KIC012557548b, are most prone to the planet-star interaction which may cause formation of the comet-like tail or another form of circum-planetary material.

We concentrate on a sample of 20 short-period exoplanet candidates with a period similar to KIC012557548b from the Kepler mission (Batalha *et al.*, 2013) and we aim to search for comet-like tails similar to KIC012557548b, or another form of circum-planetary material. The sample covers the orbital periods in the range from 0.370 to 0.708 days and the effective star temperatures in the range of $T_{eff} \simeq 3900 - 6600$ K (Batalha *et al.*, 2013). Consequently, the incident flux hitting the exoplanet may not be exactly the same as in the case of KIC012557548b, but may slightly vary by about 1-2 orders of magnitude.

We used the publicly available Kepler data from the first nine quarters in the form of PDCSAP fluxes. Only the long cadence data were considered. Kepler observations were treated and analysed similarly as in Budaj (2013). The result was a phased light-curve of the exoplanet transit. The final transit light-curve of each exoplanet candidate was fitted with the theoretical light-curve assuming a spherical dark planet transiting in front of a limb darkened star. The residuals from this fit were calculated and averaged using a running window in the same way as the observations. This enables us to search for significant fluctuations in these averaged residuals, which could indicate some form of the circum-planetary material. Theoretical light-curves and an optimum least square fit were calculated using the same method as in Krejčová *et al.* (2010). We usually computed model light-curves and residuals only from 0.35 to 0.65 (in units of phase) – near-transit residuals.

2. Results and conclusions

We applied our analysis procedure described in *Section 1* to KIC012557548b first to see which kind of signatures one could expect or search for within our sample. The shape of its averaged near-transit residuals resembles VMV letters and we refer to this kind of departures as a VMV-type of residuals. It is a signature of a circum-planetary material. Notice that in this case the averaged residuals are non-symmetric with higher fluctuation in the egress. These additional features of residuals suggest the comet-like tail (see Figure 1 – left panel).

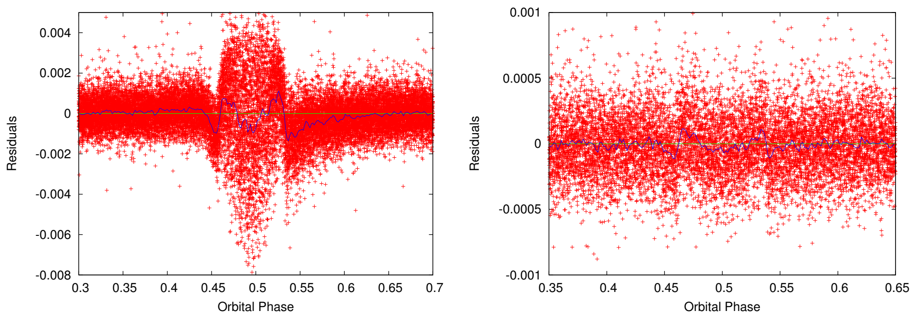

Figure 1. The near-transit averaged residuals of KIC012557548b (left panel) and KIC10975146 (right panel). We can see that the shapes of residuals are different. In the first case it is a non-symmetric VMV-type of residuals with higher fluctuation in the egress and in the second case we can see a symmetric VMV-type of residuals.

We then applied the analysis procedure to the sample. In 7 cases out of 20 we found a significant trend in the averaged near-transit residuals: in 5 cases we detected a symmetric VMV-type of residuals, in one case we found a non-symmetric VMV-type of residuals with higher scatter in the ingress and in one case we detected systematic symmetric departures and an increased scatter during the ingress and egress, which may indicate a circum-planetary material. As an example we show KIC10975146. The near-transit residuals were obtained assuming the quadratic limb darkening coefficients of 0.512 and 0.231 which were linearly interpolated from Claret (2000). *Figure 1 – right panel* shows a symmetric VMV-type of residuals, which may indicate a symmetric circum-planetary material (a circum-planetary disk). None of the candidates shows signs of a comet-like tail. This is in agreement with the theory of the thermal wind and planet evaporation (Perez-Becker, Chiang 2013). According to this model only planets less massive than Mercury can be subject to catastrophic evaporation which leads into creation of a comet-like tail. Since all exoplanet candidates have a planet-to-star radius ratio higher than 0.006, they are all likely more massive than Mercury and, consequently, lack the catastrophic evaporation contrary to KIC012557548b.

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