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Detection of small-size planetary candidates with CoRoT data

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Abstract. With the discovery of CoRoT-7b, the first transiting super-Earth, the CoRoT space mission has shown the capability to detect short-period rocky planets around solar-like stars. By performing a blind test with real CoRoT light curves, we want to establish the detection threshold of small-size planets in CoRoT data. We investigate the main obstacles to the detection of transiting super-Earths in CoRoT data, notably the presence of short-time scale variability and hot pixels.

1. Introduction

The CoRoT space mission searches for planetary transits by monitoring the optical flux of thousands of stars in several fields of view. It has recently led to the discovery of CoRoT-7b, the first transiting super-Earth (Léger et al. 2009). By simulating transits of super-Earths and Neptunes in real CoRoT light curves and searching for them blindly, we want to investigate the capability of CoRoT to detect small-size planets, super-Earths and Neptunes, in short-period orbits.

2. Simulations

We chose 500 real light curves of the CoRoT long run LRa01 which lasted 131.5 days. Central transits by super-Earths ($0.016 < k = R_p/R_* < 0.021$) with orbital period P between 1 and 15 days were simulated in 100 of the aforementioned light curves with visual magnitude $11 < V < 14.5$. In as many light curves with $12 < V < 16$, central transits by Neptune-like planets ($0.03 < k < 0.04$) were inserted. For simplicity, the parent star was assumed in all cases to be a Sun-like star ($R_* = R_\odot$ and $M_* = M_\odot$). The distribution of the simulated planets is shown in Fig. 1.

3. Data analysis

The simulated transits by super-Earths and Neptunes were searched for blindly, i.e. without knowing in advance in which light curves they had been inserted, by means of the LAM transit detection pipeline. The latter foresees the following steps:
a) a 5-sigma clipping to filter out outliers due to proton impacts during the passage of the satellite at the South Atlantic Anomaly;
b) a high-pass sliding median filter to remove stellar variability;

c) a Savitzky-Golay low-pass filter to remove high-frequency variations of instrumental origin;
d) an automatic detection and correction of the most evident hot pixels;
e) the search for transits by means of the BLS algorithm (Kovàcs, Zucker, & Mazeh 2002) with the directional correction (Tingley 2003).

4. Results and discussion

Figure 1 shows the detected planets (filled plus open circles) amongst all the simulated ones (filled circles).

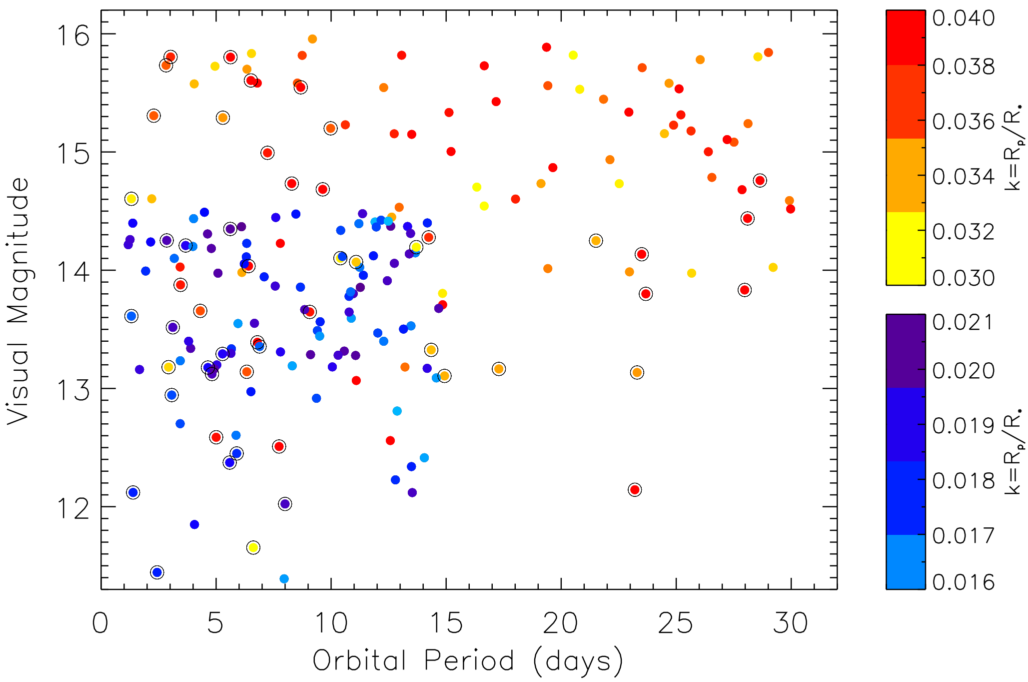

Figure 1.: *Visual magnitude of the parent stars vs orbital period of the simulated planets. Filled circles: all the simulated planets. Filled plus open circles: detected planets. Colours are a function of the ratio* $k = R_p/R_*$.

The percentage of detected super-Earths with $P < 10$ days around stars with $11 < V < 13.5$ is 35 %. 78% of Neptunes with $P < 10$ days and $V < 15$ were correctly found. Figure 2 shows the depth of the simulated transits as a function of their Signal-to-Noise Ratio (SNR). Most of the discovered transits have $SNR \geq 11$. This shows that CoRoT is able to detect super-Earths with a SNR much lower than CoRoT-7b (Fig. 2). We had no false positives.
All the undiscovered transits with $SNR > 15$ were not detected because of short time-scale (< 1.5 days) variability affecting the light curves in which they had been simulated. The undiscovered transits with $11 < SNR < 15$ went undetected because of short time-scale variability or, more often, non-corrected hot pixels.

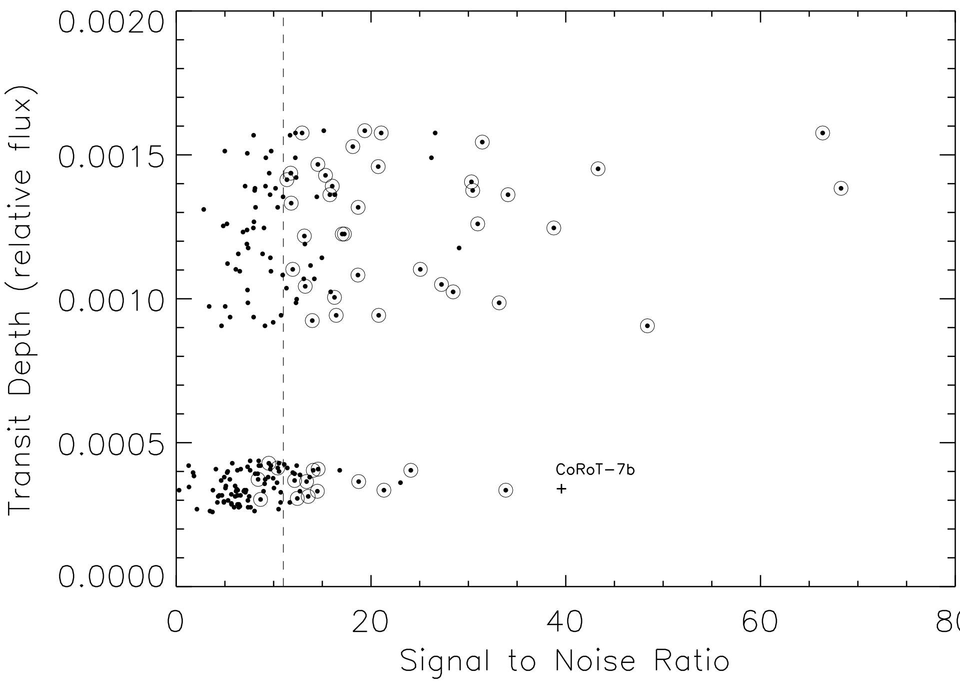

Figure 2.: *Depth of the simulated transits vs their Signal-to-Noise Ratio. Vertical dashed line: empirical detection limit at $SNR \sim 11$. The cross indicates the position of CoRoT-7b.*

Starting from the aforementioned results, work is in progress to infer some statistics on the presence of transiting low-mass planets in the CoRoT fields of view. Indeed, it is an intriguing issue to understand the reason why to date CoRoT has detected only one low-mass planet, CoRoT-7b, while both radial velocity surveys (Mayor et al. 2009) and theoretical core accretion models (e.g., Mordasini et al. 2009) indicate a pile up of planets in the Neptunian and, even more, super-Earth mass domain.

References

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