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Assuring the Legacy of the CoRoT Planets

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Abstract. For the long-lasting impact of CoRoT's planet findings, precise knowledge of the times of their transits is of vital importance for any future observing campaigns. Here we give the motivation and first results of a systematic revisit of the transits of most CoRoT planets to refine their ephemeris. As secondary objectives, more precise planet characterisations, from period or transit shape variations on/and from use of a well-defined passband may be obtained.

1 Introduction

CoRoT was launched in 2007 as the first satellite with a strong dedication to extrasolar planets, and during its lifetime achieved several important discoveries, e.g. the CoRoT-2b system [1], with a strong pattern of stellar activity; CoRoT-3b [2] and 15b [3], objects on the border between planets and brown dwarfs, CoRoT-7b [4], the first terrestrial- sized planet, CoRoT-9b [5], the first temperate transiting planet and true Jupiter-equivalent and most recently, the discovery of a planet that is likely the youngest transiting planet system known, in a stellar cluster with an age of ≈30 Myrs [6]. For the future, we expect and hope that further observations of CoRoT planets with upcoming new instrumentation will lead to continued relevant results that deepen the legacy of this mission. **For a long-lasting impact of the CoRoT planet detections, it is however of upmost importance that their transits can be observed reliably** – that is, **that we do know the time when a transit occurs with sufficient precision**, so that any future observing campaigns can be expected to be successful and does not waste time with 'hunting for the transit'.

To further show the need to improve the ephemeris precision of many CoRoT planets, we assume that for any given future transit observations, timing uncertainties of less than 1hr are desirable, while timing uncertainties of >3hrs are strongly to be avoided, since the presence of transit in a given night can then not longer be assured (and multi-night/multi-telescope campaigns would be needed to recover such a transit timing). Fig. 1 (left) shows the timing uncertainties at the middle of 2014, and as they would be in 10 years (central panel) if nothing is done (e.g. ignoring also first results from the follow-up program described here): While currently the timing of 20 planets is well known (green bars) and only 3 planets have serious (>3hrs) uncertainties (red bars), only 11 of the CoRoT planets would remain well observable in 10 years, and the majority (17 planets) would have their ephemeris 'lost'!

This situation motivated a systematic ground-based re-observation of the transits of all suitable CoRoT planets (those planets were viable transit detection can be made from), which started in late 2013. As secondary objectives, more precise planet characterisations, from period or transit shape variations and from the use of a well-defined passband may be obtained. Using several 1-2m telescopes in the Canary Islands and elsewhere, the ephemeris of currently (Oct. 2014) ten CoRoT planets have been refined, all with precisions that maintain their timing-errors below 0.5hr within the next 10 years. The transit-times of most (7) of these planets were within the 2-sigma errors of their published ephemeris. The right panel of Fig. 1 shows an example of the improvement in ephemeris-precision

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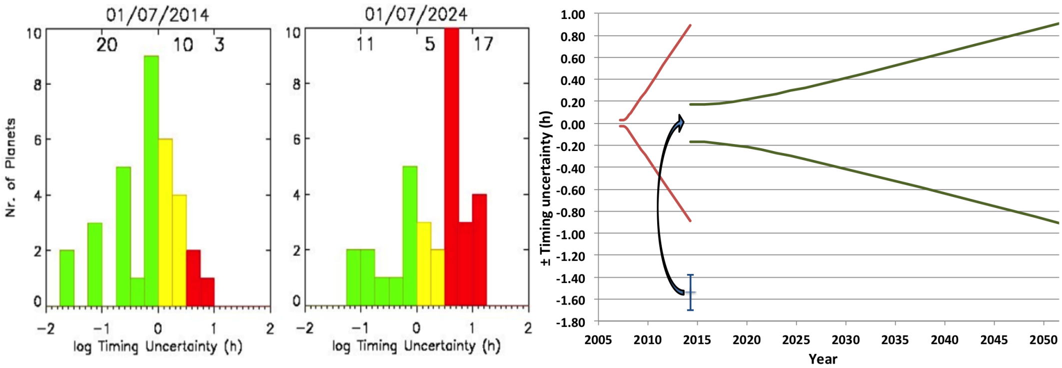

Fig. 1. Left and middle panel: Timing uncertainties (on a log-scale) of CoRoT planets in July 2014, and 10 years later. The different colours indicate uncertainties smaller than 1hr (green), of 1-3hr (yellow), and larger than 3hrs (red). The uncertainties shown are based on ephemeris from the planets' discovery publications, or from submitted publications or drafts circulating in the CoRoT exoplanet science team. For a few very recent planets, uncertainties were derived from an equation for the timing precision of single eclipses [7]. Re-observations by the follow-up program described here are not included in this figure. **Right panel:** The improvement in ephemeris precision from posterior re-observation is shown on the example of CoRoT-10b: The red-lines show the $\pm 1\sigma$ timing uncertainties from its discovery publication [8], which would have surpassed ±1 hr during 2015. An observation with the IAC80 Telescope in July 2014 found its transit-time to be 1.54 ± 0.17 h early relative to the discovery ephemeris (blue point with error-bar). The precision of this new transit timing measurement permitted the derivation of a new ephemeris (indicated by curved arrow) with an $\approx 6\times$ higher precision for the planet's period. Its timing errors are shown in the green lines. A timing uncertainty of ±1 hr won't be reached again until 2055!

that is being obtained from such observations. A second group of 3 planets displayed however transit times with ≈ 5 sigma deviations. A detailed revision is now being performed in order to determine if these large deviations are due to a true transit-timing-variation (TTV), due to some error in the *values* of the original ephemeris, or due to an underestimation of the *errors* of that ephemeris. A further 6 planets have been observed, but will need further re-observations to assure a secure detection of their transits; among them several cases with potentially large deviations against their published ephemeris. Until the end of 2015, we expect to conclude this re-observation program and publish a conclusive catalogue with updated ephemeris. Prior to this, any observers of CoRoT planet transits are invited to contact with the authors about the availability of an improved ephemeris for their target.

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