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Are Active Stars Hiding Transiting Exoplanets?

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Abstract

We discuss the results from the observations of CoRoT, especially the long runs like LRa01. These runs are an ideal test-bed for probing photometry on the level of stellar activity by the means of rotation, oscillation, stellar spots and flares. We discuss methods for analysing and filtering periodic and aperiodic stellar variability down to the level of mmag, where we expect the transit signals of an exo-Earth.

1. Introduction

Space-based telescopes like CoRoT and Kepler have been observing hundred thousands of stars with unprecedent mmag precision photometry. Recent discussions on the noise properties [1] and the level of activity of Solar-like stars [2] imply that the detection of Earth-sized is within reach. The biggest back-draw is the fact, that observed F-, G- and K-stars tend to be far more active than the well known sun. This impairs the proper detection of small planets like CoRoT-7b [3] and Kepler-10b [4] and complicates their confirmation with radial-velocity.

2. Methods

We investigate the long observation run of CoRoT LRa01 [5] which lasted 150 days and contains 7470 chromatic photometric data sets. We selected a subset of 2000 brightest stars in the domain of $\text{mag}_R = 8 \ldots 11$. Each lightcurve is sampled with 512s in general [6], interesting targets are sampled in 32s. We removed datapoints, which were flagged as bad (e.g. due to the satellites crossing of the SAA) as well as outliers above 5σ and rebinned the data to 512s to equidistant times. The chromaticity was exploited for a alternate and refined spectral classification and for discrimination between stellar effects and pixel artefacts.

Periodic variations of the stellar flux, like the rotation period of the stars P_{rot} or the pulsation and oscillations and their harmonics were determined by cumulating the Fourier autocorrelation of the lightcurves using a rectangular windowing function. An additional correction was applied to compensate for the non-infinite length of the autocorrelation, which penalizes the longer periods. Additionally a second order polynomial was subtracted to minimize the effect caused by observational trends.

Aperiodic stellar variability was measured using sliding rms windows of variable length in all three colours.

Stellar oscillations and pulsations were identified by a windowed Fourier transform.

3. Results

As shown in Fig.1 the rotational periods, which are caused by stellar spots, but also bright features on the star are commonly around 70 days. Contact binary systems and pulsators govern the period domain below 15 days. Giant and dwarf stars can be found well above 50 days, with respect to the uncertainties of the used method.

If we look at the pulsations in detail, we find that their amplitudes are in the magnitude of neptunes. Most of the Earth sized planets are burried below at least the half of the pulsating stars.

The noise level for the stars at the given time scale for the transit durations of the planets at 1, 5.2 and 30.1 AU are between the mmag and ppm level.

4. Summary and Conclusions

The stars' activity hosting an exoplanet is still an unknown domain. Looking at the occurrence of rotational periods might reveal the difficulty to detect longer transit periods above the 60 days limit. This will surely change in the near future, when long term observations will become available through Kepler or Plato.

Periodic variability buries the transit signals of Earth-sized and most of the Neptune-sized planets.

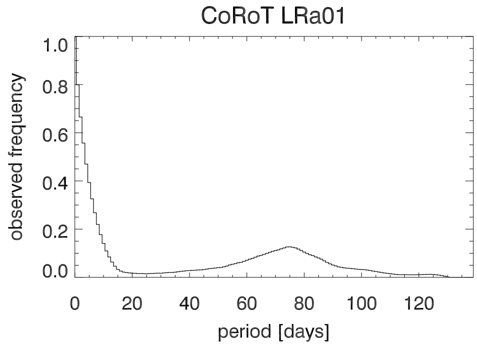

Figure 1: The number of rotational periods P_{rot} of the investigated stars are shown. Lower periods than 10 days are contaminated by pulsations, that could not be clearly identified. Generally eclipsing binaries and especially contact binaries dilute the statistics and add a constant bias. Values above 120 days have a larger uncertainty caused by the window-function of the Fourier autocorrelation.

Tools like pre-whitening or other filtering techniques are necessary to unveil those detections.

Aperiodic noise seems to be no problem for the detection of all sizes of planets at semi-major axes expected from the solar system. Looking for Earth-sized planets with a transit depth of 84 ppm is still a difficult task.

References

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