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EXAMINING TESS LIGHT CURVE TO SORT OUT SOPHIE PLANET CANDIDATE

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Abstract. Since stellar activity is a dominant source of noise in both photometric and radial velocity (RV) surveys, a deeper understanding of its effects is essential for accurate exoplanet detection and characterization. Photometric data of Transiting Exoplanet Survey Satellite (TESS) offers us an opportunity to investigate the radial velocity jitters induced by stellar activities through photometric variabilities. In this project, we used the SOPHIE (1.93m-OHP) RV measurements and TESS photometry data in order to 1) evaluate the activity of the host star of the SOPHIE planet candidates; 2) investigate the likely activity-induced RV variations; 3) try to detect a new planet signal in photometry data. We present the result of our current analysis and how it can help for making an efficient observation planning for the future SOPHIE surveys.

Keywords: methods: data analysis, stars: activity, techniques: radial velocities, techniques: photometric

1 Introduction

It is well known that the presence of stellar activity can interfere with spectroscopic and photometric observations of exoplanets, leading to false detection or missing signals from the radial velocity (Rajpaul et al. 2015; Díaz et al. 2016). Stellar activity can also influence the accurate determination of exoplanet parameters (Barros et al. 2014). It is therefore quite important to identify and characterize the stellar activity in order to distinguish it -as accurately as possible- from the variations caused by exoplanets. Using simultaneous RV and photometric measurements delivers a wealth of information about the stellar activity, a key to evaluating the activity of host stars and having accurate data analysis. For this purpose, here, we used the SOPHIE RV measurements and TESS photometry data.

2 Activity induced RV variations

By analyzing the SOPHIE RV measurements and TESS photometry data, we successfully removed some false positives of SOPHIE planet candidates. As an example, in Fig. 1 top-left, we plotted the RVs periodogram of one of the SOPHIE targets which illustrates a significant peak with false alarm probability (FAP) of below 1 % at 5.9 d. The same peak was found in periodogram of bissector span. Our investigation in the TESS light curve shows that the star is very active. Moreover, the posterior distribution of stellar rotational period using the Gaussian Processes (GPs) model shows a peak at 12 d. Considering the star is very active and there is a corresponding peak in the activity indicator, it is likely that the RVs signal at 5.9 days is half of the rotational period peak at 12 d.

3 Detecting transit signals

Among the exoplanet population, transiting planets have a considerable impact. They can be characterized accurately in mass and in radius, hence giving access to their mean bulk composition.

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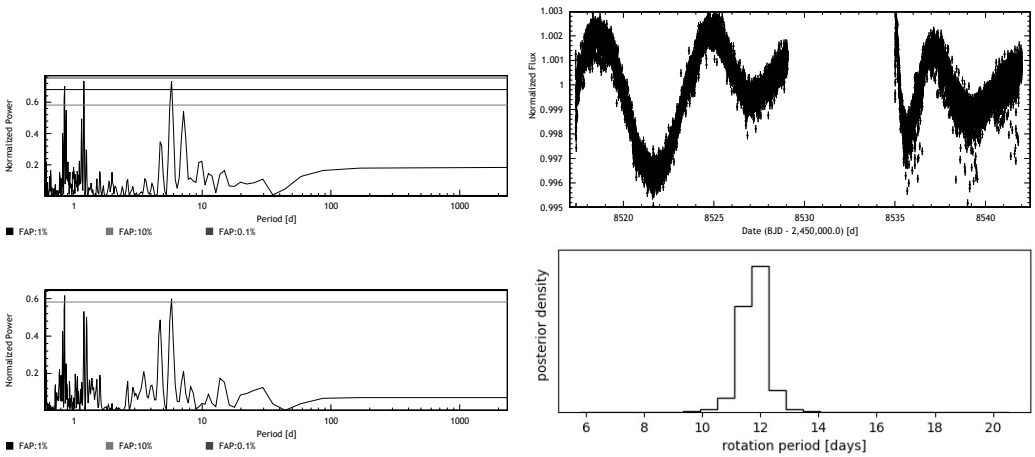

Fig. 1. Right: periodogram of RVs (*top*) and bissector span (*bottom*) of one of the SOPHIE targets. **Left:** TESS light curve of the target (*top*) and the posterior distribution of stellar rotational period using the Gaussian Processes (GPs) model (*bottom*).

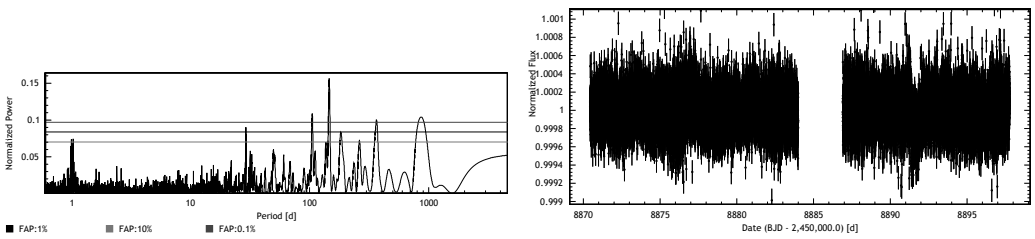

Fig. 2. Right: RVs periodogram of one of SOPHIE targets. **Bottom:** solo transit signature of the target in TESS light curve.

To detect such interesting planets, we searched the TESS light curve of the SOPHIE planet candidates. To do so, we used the transit-least-squares (TLS) algorithm (Hippke & Heller 2019), a method to investigate planetary transits taking into account the stellar limb-darkening and also the effects of planetary ingress and egress. In Fig. 2, we plotted a solo transit which we found in TESS light curve. An analysis of RV measurements shows us a strong peak with FAP of below 0.1 % at 147 d and a lot of other peaks everywhere in the periodogram (see Fig. 2 top). The solo transit can be the signature of each of these candidates. We have a plan to determine the phase of the RVs through combing with TESS photometric data to identify which candidate it might be. Moreover, TESS will re-observe this star in February and provide us more information about this system.

4 Conclusions and next work

In the target selection for the observation plan, it is necessary to define priority and have an observation strategy for each star. To do so, a better understanding of the star activity is essential. Such work will greatly help in evaluating the activity of stars and having accurate data analysis. We plan to continue this work with current and future SOPHIE and TESS observations.

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