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MEASURING STELLAR ROTATION AND ACTIVITY WITH PLATO

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Abstract. Due to be launched late 2026, the PLATO mission will bring the study of main-sequence solar-type and low-mass stars into a new era. In particular, PLATO will provide the community with a stellar sample with solar-type oscillations and activity-induced brightness modulation of unequalled size. We present here the main features of the analysis module that will be dedicated to measure stellar surface rotation and activity in the PLATO Stellar Analysis System.

Keywords: PLATO, stellar physics, stellar rotation, stellar activity

1 Introduction

The Planetary Transit and Oscillations of stars (PLATO, Rauer et al. 2014) mission will provide high-cadence photometric light curves for hundreds of thousand of solar-type stars. The Module for Stellar Astrophysics number 4 (MSAP4), currently under development, is the PLATO pipeline component dedicated to analyse stellar surface rotation and surface magnetic activity including magnetic cycles in the light curves acquired by the mission.

2 The MSAP4 module

2.1 General framework

The flow diagram of the MSAP4 module is shown in Fig. 1. Using the stellar light curve and corresponding periodogram, MSAP4 will perform several analyses in order to provide values for the spectral background components (Corsaro & De Ridder 2014; Corsaro et al. 2015), the logarithm of surface gravity, log g (Bugnet et al. 2018), the average surface rotation period, $P_{\rm rot}$, the photometric activity index, $S_{\rm ph}$ (Mathur et al. 2014), the Rossby number, Ro (Noraz et al. 2022), and long-term variability periods, $P_{\rm cycle}$. The demonstration code for MSAP4 is fully open-source[*] and modular, with dedicated documentation and tutorials[†].

2.2 Extracting rotation

For stars ranging from M- to F- type, MSAP4 will measure surface rotation periods. To ensure robustness of the analysis, rotation-related parameters are extracted with several methods. In MSAP4-01, Fourier analysis is performed with the generalised Lomb-Scargle (GLS, Zechmeister & Kürster 2009). In MSAP4-02, a time series analysis is performed by computing the autocorrelation function (ACF, McQuillan et al. 2013) In MSAP4-03, the two methods are combined to enhance common periodicities, yielding the composite spectrum (CS, Ceillier et al. 2016). These results are combined using the machine-learning methodology Random fOrests Over STEllar Rotation (ROOSTER, Breton et al. 2021). In particular, ROOSTER will provide a reliability score for the measured period. $S_{\rm ph}$ and Ro are finally computed using the measured $P_{\rm rot}$.

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[*]The source code can be downloaded here: `https://gitlab.com/sybreton/plato_rotation_pipeline`.
[†]The documentation is hosted here: `https://plato-rotation-pipeline.readthedocs.io/en/latest/`.

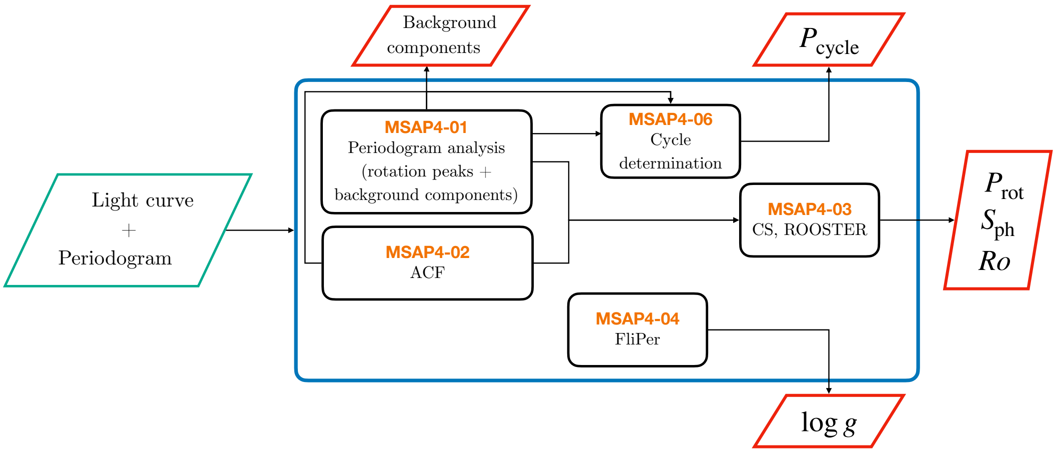

Fig. 1. Flow diagram of the MSAP4 module.

2.3 Looking for cyclic modulations

In addition to surface rotation measurements, long-term variability in the light curves will be searched: solar-type magnetic activity cycle, but also shorter cycle such as Rieger-like cycles (Rieger et al. 1984). To this purpose, measurements from the GLS, the ACF, and the $S_{\rm ph}$ modulation will be combined.

3 Conclusions

PLATO will enable to obtain new insights on the interaction between rotation and activity in main-sequence low-mass stars. Combined with the asteroseismic measurements that the mission will also perform, it will provide an unprecedented sample of stars with exquisite characterisation.

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