Stars and their variability observed from space
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A PRE-MAIN SEQUENCE VARIABILITY CLASSIFIER FOR TESS

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Abstract. We present a new variability classifier to identify pre-main sequence (pre-MS) stars observed by the Transiting Exoplanet Survey Satellite (TESS) mission. We present 4 indicators to characterize this type of star and briefly suggest how this classifier can be used in the future.

Keywords: Stars: pre-main sequence, Methods: statistical, Stars: variables: T Tauri, Herbig Ae/Be

1 Introduction

The identification of pre-MS stars is a notoriously hard task, as young stars are indistinguishable from their post-MS counterparts in the HR-diagram. The distinction of these two types of evolutionary stages is usually done by including observational features typical for the pre-MS phase to associate stars to young star forming regions, assuming that the members of these regions formed at the same time. We present an alternative methodology which takes into account four indicators of pre-MS nature as part of the classification scheme in the TASOC* collaboration. In the following we describe the individual indicators used in the classification scheme.

2 Identifying T-Tauri objects

T-Tauri objects are low-mass pre-MS stars with a unique light-curve (LC) morphology. These objects generally show either regular variability, semi-regular variability or irregular variability. For this work we consider only the semi-regular variable T-Tauri stars. If we can identify and find this type of variability in a given star, we can conclude that it is a pre-MS object. The indicator consists of a three-step algorithm (as indicated by box **1.** in Fig. 1):

1. Initially, we smooth the high-frequency variation in the LC. We then count the number of zero crossings, giving an initial approximation for the period in the variability P'_{var}.
2. We apply the phase dispersion minimization (PDM) technique (Stellingwerf 1978) to the LC. Using P'_{var} from step one, we search for the closest dominant period in the PDM, P_{var}, which we apply in step three.
3. The light curve is phase-folded with P_{var}. We then count the number of minima N_m in the phases, and if that number is equal for all periods we define this star as a semi-regular T-Tauri object.

3 Gaia astrometry and young stellar clusters

We also use the classical approach for the identification of pre-MS stars by their association with young clusters. To find young clusters and their member stars, we use the catalogues of visible clusters from Dias, W. S. et al. (2002), Cantat-Gaudin et al. (2018) and Sampedro et al. (2017). Each individual star is assigned a pre-MS probability according to its position in its evolution, taking the age of the cluster into account as well as the different evolution time-scales for different masses. This is indicated as box **2.** in Fig. 1.

4 Gaia flux uncertainty as a proxy for variability

Applying the methodology from Vioque et al. (in prep.), one can use the Gaia (Gaia Collaboration et al. 2016) flux error as a variability indicator and as a proxy for pre-MS stars. With a specifically trained neural network (indicated by box **3.** in Fig. 1), we can assign pre-MS probabilities to stars based on the Gaia flux error as well as on some other parameters available from Gaia.

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*https://tasoc.dk/

5 Variability tree classifier

Many pre-MS stars show strong irregular variability during the early phases of their evolution. We can make use of that by applying the methodology from Valenzuela & Pichara (2018). In their work they describe an algorithm to create a variability tree classifier; it is described there in detail.

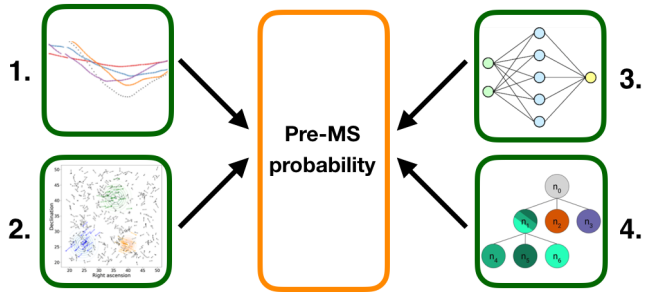

Fig. 1. Overview over the four indicators used in the classification scheme. Box 1. illustrates the identification of T-Tauri objects, 2. the use of Gaia astrometry and cluster association, 3. shows a schematic neural network used to identify pre-MS stars by considering the Gaia flux error, and 4. shows the populated variability tree.

6 Conclusion

We have presented a novel way to distinguish pre-MS stars from their more evolved counterparts. We showed four distinct ways to classify pre-MS stars, each with their unique strengths. This classifier will be a part of the TASOC classification scheme, and will be applied to all the stars in the TASOC catalogue.

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