A-F variable stars from the northern TESS continuous viewing zone

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Abstract: We present preliminary results of the identification of the variable stars brighter than 11 mag among A- and F-type stars in the northern TESS continuous viewing zone (CVZ). The aim of our efforts is to identify good candidates for the spectroscopic follow-up observations. We found out that about 63 % of all stars show some kind of variability. About one third of the investigated stars shows a combination of variability types.

Methodology: Based on the TESS Input Catalogue v8 (Stassun et al. 2019), we selected stars brighter than 11 mag with effective temperatures between 6000 and 10000 K (A-F type) that are located within a circle with diameter of 15 degrees from the northern ecliptic pole (5927 stars). Subsequently, we created frequency spectrum for each target and classify the stars based on the frequency content in different frequency regimes including visual inspection of the light curves. We adopted the variability types from the Variable Star Index (Watson et al. 2006). The star was marked as variable only when the peak has signal-to-noise ratio SNR>6, if the SNR is between 4 and 6, the stars is only a candidate. The examples of the figures used for the classification are shown in Fig. 1.

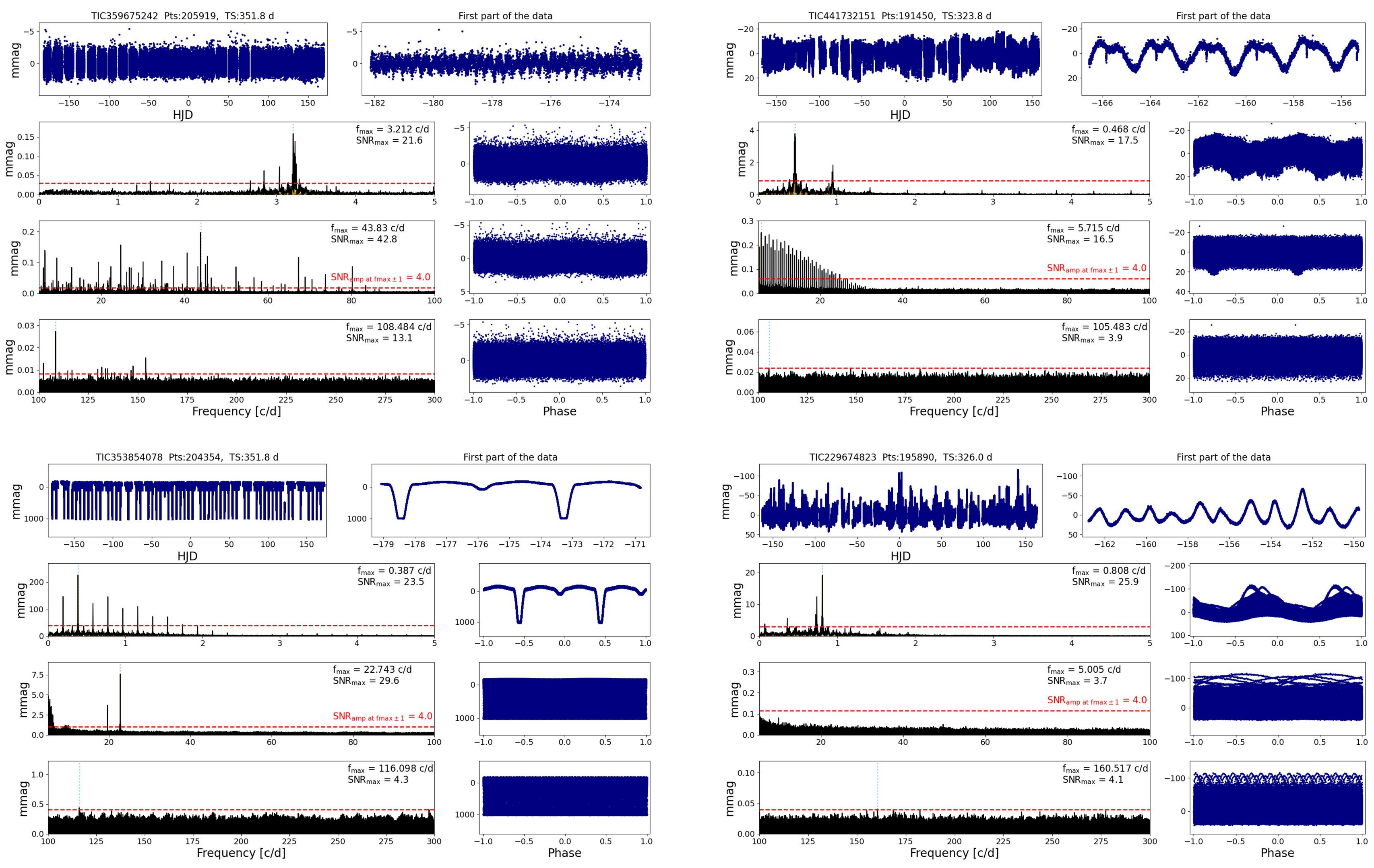

Figure 1. Examples of classification figures. For each star we plotted the full data, the first sector of the data, frequency spectra in three regimes: GDOR (0-5 c/d), DSCT (5-100 c/d) and roAp (>100 c/d), and the data phase-folded with the highest peak in a given regime. The top left panel shows star classified as GDOR+DSCT which contains also peaks in the roAp regime, the top right-hand panel shows star classified as ROT+EB, the bottom left panel shows EB+DSCT and the bottom right-hand panel shows GDOR. The SNR=4 limit defining the variable stars is shown with the red dashed line.

Interesting cases: Fig. 1 shows examples of interesting stars. The top left panel shows TIC 359675242 that is a GDOR and DSCT pulsating variable (hybrid). In addition, its frequency spectrum contains also roAp peaks, which, however, can be combinations of lower-frequency peaks. TIC 441732151 (top right-hand panel of Fig. 1) is a star showing rotational variability with amplitude varying in time in combination with eclipses. This is a similar case to HD 99458 that is suspected to be a chemically peculiar star in a tight binary system (Skarka et al. 2019). We identified 9 such cases in the northern TESS CVZ. The bottom left panel shows an already known eclipsing binary SW Dra that contains a pulsating star of DSCT type. The bottom right-hand panel shows pulsating star TIC 229674823 of GDOR type that can be classified as high-amplitude GDOR (Paunzen et al. 2020).

Binaries with a DSCT component: We searched for the binary stars among DSCT pulsators by employing the phase-shift method (Murphy et al. 2014). We divided the data with respect of the gaps to segments with the length of at least 8 days and searched for the time delays by using 8 and 2 most prominent frequency peaks in the DSCT and GDOR regimes, respectively (see Fig. 2). We identified 40 binary candidates from which a dozen (including the two stars shown in Fig. 2) are being monitored spectroscopically with the 2-m Perek telescope in Ondřejov (Czech Republic, Fig. 4).

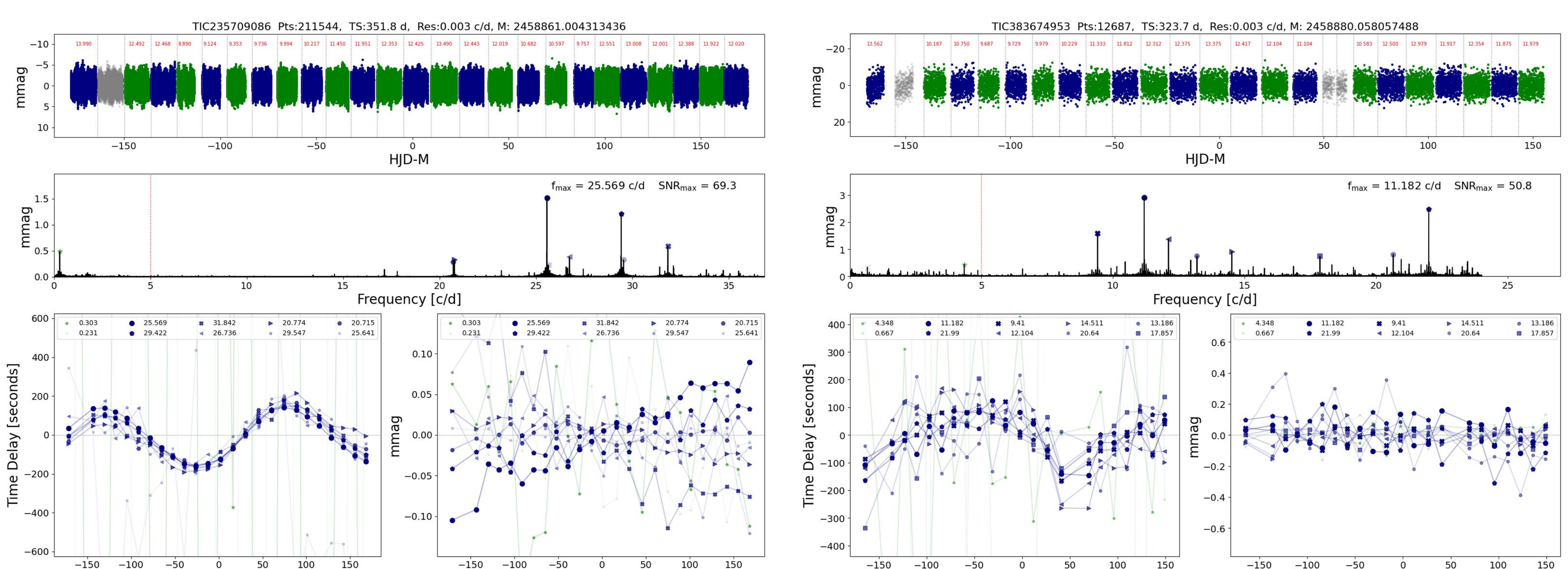

Figure 2. Two binaries containing DSCT stars showing the light-travel time effect. Figures for both stars contain plots of the data divided according to gaps, frequency spectrum with the identification of the most prominent peaks, the time-delay graph and the variation of the amplitude of the peaks.

References:

Dupret et al. (2005), A&A, 435, 927
Murphy et al. (2014), MNRAS, 441, 2515,
Murphy et al. (2019), MNRAS, 485, 2380
Stassun et al. (2019), AJ, 158, 138
Skarka et al. (2019), MNRAS, 487, 4230
Paunzen et al. (2020), MNRAS, 499, 3976
Watson et al. (2006), 25th Annual Symposium, The Society for Astronomical Sciences, 47

The results: About 63 % of almost 6000 stars in our sample show some kind of variability, 187 variables (3 %) have already been known. More than 50 per cent of the variables show peaks in the GDOR regime (<5 c/d) pointing towards ROT and GDOR variability. However, in many cases we were not able to distinguish between these two types, thus, we give the combination of the types ROT/GDOR in the histogram in Fig. 3. The trouble of proper identification of ROT and GDOR types is also apparent from the HRD in Fig. 3 - lots of ROT stars are actually grouped in the GDOR instability strip (IS). About 10 % of stars show pure DSCT variability, 30 % of stars show both GDOR and DSCT type pulsations. All variability types are spread over the whole range of luminosity and temperature.

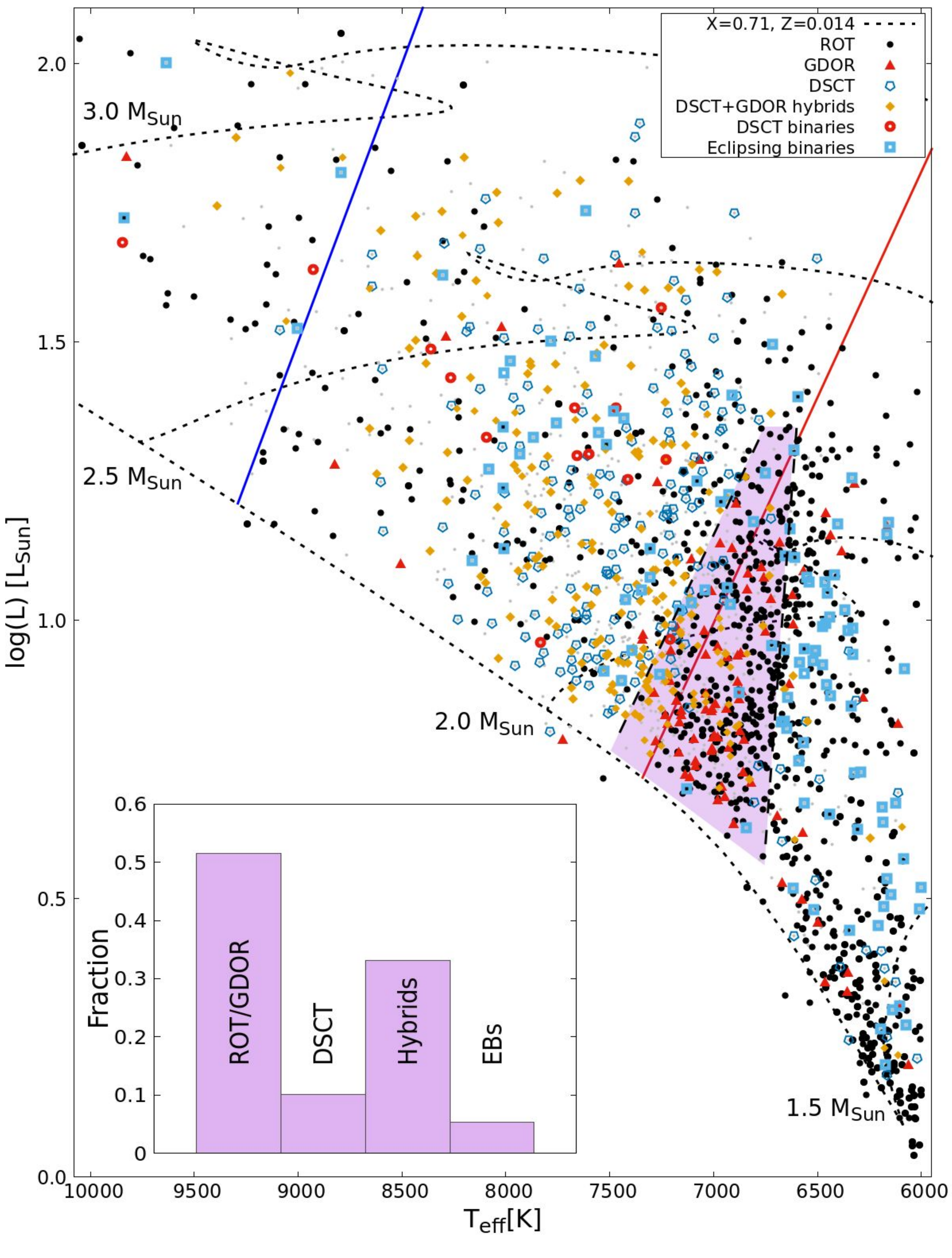

Figure 3. HRD showing 2000 stars from our sample having the most prominent variability. The blue and red continuous lines show the empirical DSCT IS defined by Murphy et al. 2019, the violet-shaded area shows the theoretical GDOR IS (Dupret et al. 2005). The ZAMS and evolutionary tracks are taken from Murphy et al. 2019. The inset shows the distribution of the most numerous variability types.

Future plans and spectroscopic follow-up: The results shortly presented here will be detailed and elaborated in a paper by Skarka et al., which is being prepared. We started spectroscopic observations with the echelle spectrograph OES mounted on the 2m Perek telescope in Ondrejov, Czech Republic (Fig. 4). The targets being observed are stars showing signs of rotational variability in combination with DSCT pulsations and eclipses, eccentric binaries, and DSCT binaries identified through the phase shifts.

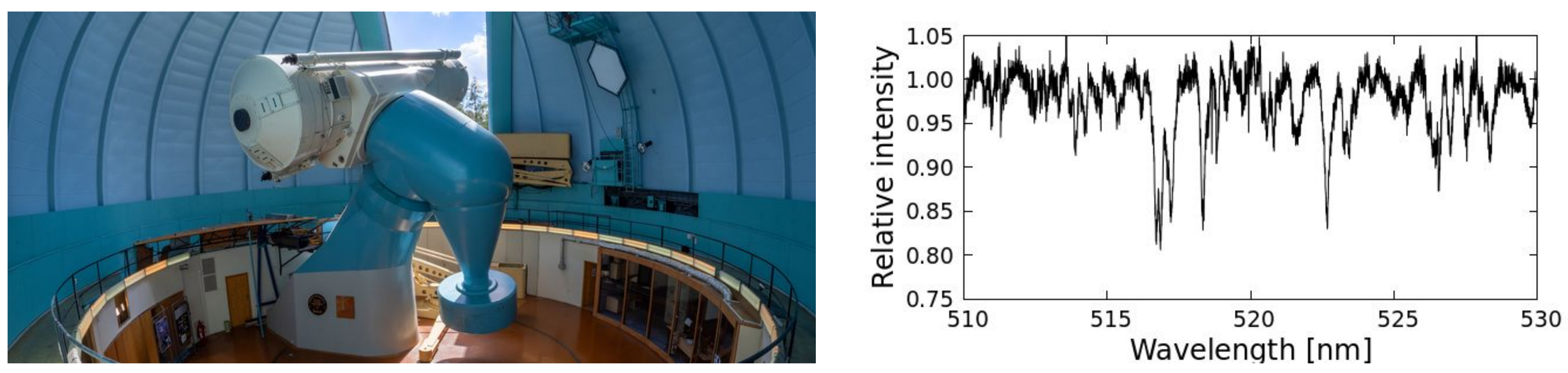

Figure 4. The 2-m Perek telescope in Ondřejov, Czech Republic (left panel). The right-hand panel shows a part of the normalized spectrum of TIC 235709086 around the Mg triplet.

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