Spectroscopic observations of chemically peculiar Am candidates observed by TESS satellite

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Pulsating Am stars

The metallic-line (Am) stars are chemically peculiar A and early F stars that show weak spectral lines of Ca K and Sc and strong Fe-group features compared to their H-line spectral type. If the Ca K line indicates spectral type at least 5 times earlier than that resulting from metal lines, the star is defined as classical Am star. For marginal Am stars (Am:) the discrepancy is smaller. The abundance peculiarities of Am stars can be explained by chemical separation due to radiative diffusion and gravitational settling.

The metallic-line stars are located in the classical instability zone, where pulsating δ Scuti stars lie. The δ Scuti pulsations are driven by the κ-mechanism operating in the He II ionisation zone. It has long been held that metallic-lined (Am) stars have a much lower incidence of pulsation than normal stars because of atomic diffusion of helium out of the He II partial ionisation zone. Smalley et al. (2017, MNRAS, 465, 2662) found that δ Scuti pulsations in Am stars are mostly restricted to the effective temperature range $6900 < T_{\rm eff} < 7600$ K, inside the broader area where chemically normal δ Scuti variables are located. Moreover, the incidence of pulsations in Am stars decreases with increasing degree of chemical peculiarity, so marginal Am stars pulsate more often than classical Am stars. However, the maximum amplitude of the pulsations does not significantly depend on the degree of peculiarity and amplitudes of the main pulsation frequency are similar for A and Am stars.

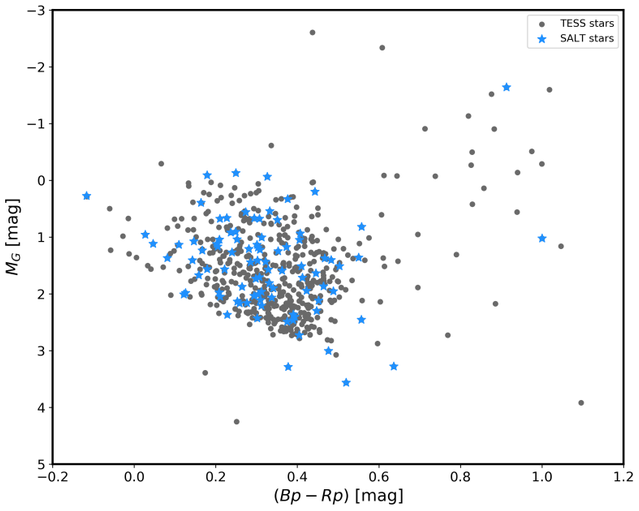

Figure 1. Colour-magnitude diagram for Am candidates created using Gaia-EDR3 photometry. Black filled circles indicate all Am candidates observed with TESS in 2-min cadence, stars observed also with SALT are plotted with blue stars.

A direct evaluation of the effect of the Am peculiarity on pulsations is now possible because the TESS satellite gives us a high-precision and homogeneous view of the pulsations of a large sample of Am stars. Observations at 2-minute cadence of more than 600 Am candidates with the TESS satellite constitute a unique data set to make a meaningful analysis.

SALT observations and spectral classification

High-resolution (R=65,000), high signal-to-noise (S/N=200 at λ = 5000 Å) spectra of a sample of 95 southern Am candidates were obtained with the HRS@SALT. All spectra were calibrated and reduced by dedicated pipeline and normalised with SuppNet[1].

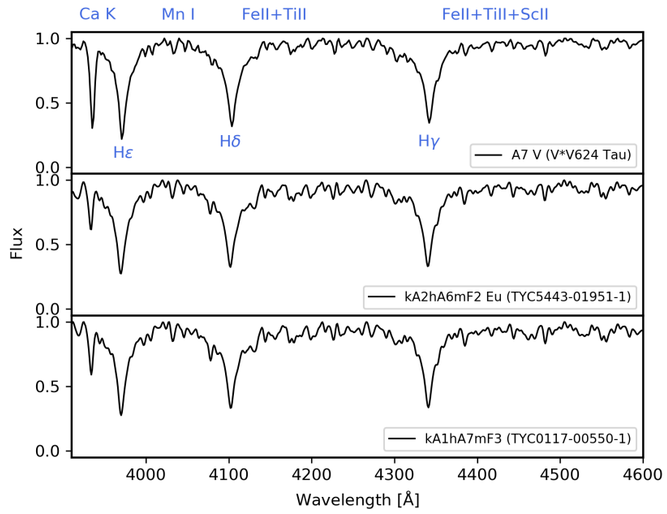

Figure 2. Spectra of two Am stars (TYC5443-01951-1, TYC0117-00550-1) in comparison with the standard star V624 Tau. The classification is given in the legend. In addition, the location of the lines important for spectral classification are presented.

The spectral classification was performed in two steps. In the first step, the automatic code MKCLASS[2] was used. This program is prepared to classify spectra in the range 3800-5600 Å via direct comparison with Morgan-Keenaan standards. In the classification process we used the one based on flux calibrated spectra with the spectral resolution R≈1100, obtained with the Dark Sky Observatory (Appalachian State University) 0.8-m telescope. To use this library, it was necessary to degrade the resolution of the SALT spectra to R=1100, and to limit them to the 3800-5600 Å spectral range. To prepare the spectra, we used the auxiliary programs distributed with MKCLASS. In the second step, the automatic spectral classification was visually checked by using the graphics program xmk25. It turn out, that for some stars the MKCLASS automatic classification has to be changed.

The spectral classification revealed that more than a half of the Am candidates are indeed Am or Am: stars. In addition, some chemically peculiar Ap and one λ Boo star were discovered. However, 39 analysed stars appeared to be chemically normal B, A or F stars.

Results and future work

The TESS photometric time-series were analysed for all stars observed by the SALT telescope. Most of the stars was classified as constant on the basis of TESS data. Only 10 out of 56 stars classified as chemically peculiar Am or Am: objects shows pulsations of δ Scuti type. All of them have effective temperatures in the range 7000-8000 K but only three of them fall within the range obtained by Smalley et all. (2017, MNRAS, 465, 2662).

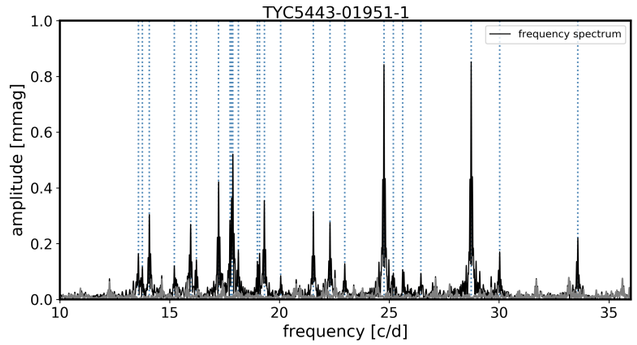

Figure 3. Frequency spectrum of TYC5443-01951-1, classified as classical Am star. Obtained frequencies are indicated with blue dotted lines. Both, original frequency spectrum (black line) and these cleaned for 25 frequencies (grey line) are given for comparison.

We plan to perform the detailed analysis of all the collected spectra. This will allow us to determine atmospheric parameters, chemical composition, and projected rotational velocities of all targets. This information is necessary to fully understand the TESS satellite observations of these stars. The precise photometric time series gathered by TESS will help us answer several questions regarding the incidence of pulsations in Am stars, dependence of pulsation characteristics on atmospheric parameters, chemical abundances, and projected rotational velocities. Moreover, the analysis of the TESS photometric data supplemented with the results of spectroscopic analysis are the necessary ingredients of stellar seismology, the only method allowing us to understand the inner structure of a star.

[1] https://rozanskit.com/suppnet/
[2] http://www.appstate.edu/ grayro/mkclass/