

Rapidly-oscillating *TESS* A–F main sequence stars: are the roAp stars a distinct class?

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Accepted Received ...

ABSTRACT

From sector 1–44 *TESS* observations, 19 new roAp stars, 103 ostensibly non-peculiar stars with roAp-like frequencies and 617 δ Scuti stars with independent frequencies typical of roAp stars were found. Examination of all chemically peculiar stars observed by *TESS* resulted in the discovery of 199 Ap stars which pulsate as δ Sct or γ Dor variables. The fraction of pulsating Ap stars is the same as the fraction of pulsating chemically normal stars. There is no distinct separation in frequency or radial order between chemically peculiar δ Sct stars and roAp stars. In fact, all the features which originally distinguished roAp from δ Sct stars in the past have disappeared. There is no reason to assume that the high frequencies in roAp stars are driven by a different mechanism from the high frequencies in chemically normal stars. However, chemically peculiar stars are far more likely to pulsate with high frequencies. The term “roAp” should be dropped: all roAp stars are normal δ Scuti stars.

Key words: stars:oscillations; stars: chemically peculiar

1 INTRODUCTION

The peculiar Ap and Fp stars have strong, approximately dipolar, kilogauss global magnetic fields with axes which are generally tilted with respect to the rotation axes. They have inhomogeneous surface abundances and brightness, leading to rotational light modulation (the oblique rotator model [Stibbs 1950](#)). Their spectra have unusually strong lines of some ionized metals (e.g., Sr, Cr) and rare earth elements. The chemical peculiarities, which are confined to the outer layers, are thought to be a result of radiative acceleration, gravitational settling and diffusion.

The rapidly-oscillating Ap (roAp) stars are Ap/Fp stars which pulsate in a limited high-frequency range, typically above 60 d^{-1} ([Kurtz 1978, 1982](#)). When roAp stars were first discovered, the highest frequencies then detected among the δ Scuti stars were around 50 d^{-1} . These frequencies could be understood by the operation of the opacity driven κ mechanism in the HeII partial ionization zone ([Cox 1963](#)). The higher frequencies seen in roAp stars, however, could not be reproduced by models and seemed to require a new driving mechanism. For this reason, it seemed appropriate to make a distinction between δ Sct and roAp stars.

An additional reason why roAp stars were thought to be distinct from δ Sct stars is that high frequencies only seemed to occur among the chemically peculiar Ap stars. Furthermore, while δ Sct stars pulsate in a broad range of frequencies, the roAp stars pulsate with just a single high frequency or else with multiple closely-spaced high frequen-

cies. Another important difference is that in some roAp stars the frequency peaks are split by an exact multiple of the rotation frequency, something which is never seen in δ Sct stars. This can be understood by the oblique pulsator model ([Kurtz 1982; Kurtz & Shibahashi 1986](#)), in which the pulsation axis is tilted with respect to the rotational axis.

In conventional models, pulsational driving due to the κ mechanism acting in the H/He I partial ionization zone is almost enough to overcome damping in the rest of the star. This led [Balmforth et al. \(2001\)](#) to suggest that suppression of convection by a vertical magnetic field might be sufficient to reduce damping, resulting in driving of high-frequency pulsations confined to the region around the magnetic poles (see also [Cunha 2002, Cunha et al. 2013](#)). This new model seem to finally solve the problem of pulsational driving in roAp stars and explained why a strong magnetic field is required for the pulsations to occur. Since pulsational driving occurs only at the poles, the model neatly justifies why only axisymmetric modes are seen and the oblique pulsator model.

Further attempts to understand high-frequency pulsations in δ Sct stars were made by [Antoci et al. \(2014\)](#) who highlighted the role of turbulent pressure in the envelope convective zone. It was found that high frequencies could be excited in certain regions of the H–R diagram. Turbulent pressure is also considered as a possible mechanism in driving pulsations in Am stars ([Smalley et al. 2017](#)). The most comprehensive recent modelling of pulsations in δ Sct stars is that of [Xiong et al. \(2016\)](#), which also involves turbulent

pressure. The models predict high frequencies in a limited region of the H–R diagram.

Observations from the *Kepler* mission were the first to challenge the perception that pulsations in the δ Sct stars are fully understood. The models are unable to reproduce the low frequencies (i.e. below 5 d^{-1}) which are ubiquitous in δ Sct stars even at the highest effective temperatures (Balona 2014). Neither can they reproduce the fact that both γ Dor and δ Sct stars co-exist in the same effective temperature and luminosity region (Balona 2018). Another problem is that less than half of the stars in the δ Sct instability region seem to pulsate (Balona 2018).

TESS observations have also shown that high frequencies are not unique to roAp stars. Some δ Sct stars have independent frequency peaks extending into the roAp frequency range (Balona et al. 2019; Bedding et al. 2020). In this paper we present a list of 617 δ Sct stars with independent frequencies higher than 60 d^{-1} . These are chemically normal stars, showing that high frequencies are not confined to chemically peculiar stars. This invalidates the need for a special driving mechanism involving strong magnetic fields and suppression of convection at the poles (Balmforth et al. 2001).

Furthermore, many ostensibly normal A–F stars pulsate in isolated high frequencies or tight high-frequency groups just as in roAp stars (Cunha et al. 2019; Balona et al. 2019). Many of these have turned out to be chemically peculiar (Holdsworth et al. 2021), but this may not be true for all stars. In this paper we present more than 100 additional chemically normal stars with frequencies and frequency distributions that cannot be distinguished from roAp stars.

In this paper we also present the results of a survey of 1978 *TESS* Ap stars and the discovery that 199 are δ Sct or γ Dor stars. The idea that Ap stars do not pulsate is not correct. These new discoveries show that all the characteristics separating roAp stars from δ Sct stars are no longer applicable. It is clear that whatever mechanism drives high frequencies in normal stars must surely drive the high frequencies in “roAp” stars as well. The equally-spaced frequencies seen in some roAp stars are not seen in normal δ Sct stars. This is due to the action of a strong magnetic field on the atmospheric structure and does not require a separate pulsation mechanism.

The aim of this paper is to present new discoveries of “roAp” stars and non-peculiar roAp-like pulsators as well as a survey of pulsation in chemically peculiar stars. Using these results, it is argued that a suitable definition of the roAp class does not exist. Furthermore, it is argued that there is no criterion, other than a purely arbitrary frequency criterion, which can distinguish roAp stars from chemically peculiar or chemically normal δ Sct stars. It is concluded that the roAp classification is no longer a helpful guide to understanding pulsations in A–F stars and that the name “roAp” is misleading and should be abandoned.

2 THE DATA AND STELLAR PARAMETERS

The *TESS* photometric survey consists of continuous wide-band photometry of 13 sectors per celestial hemisphere. Each sector is observed continuously for about 27 days with 2-min cadence. Stars near the ecliptic equator are only ob-

served for one sector. Stars in the circular regions nearer the poles overlap so that, at the ecliptic poles, stars are observed continuously for about 100 days. The light curves are corrected for time-correlated instrumental signatures using pre-search data conditioning (PDC, Jenkins et al. 2016). The data used here are the full PDC light curves from sectors 1–44.

It should be noted that the *TESS* pixel size is 21×21 arcsec, which is roughly the size of the aperture used in ground-based photoelectric photometry. There is a possibility of contamination due to other stars in the same aperture. However, the stars discussed here are bright, mostly in the range 8–10 mag. The chances of contamination by another star of comparable brightness is quite remote. Contamination by a binary companion of comparable luminosity would be impossible to verify.

The most important step in any survey of this nature is to determine the variability type of each star. Automated classification is a relatively simple task, but without visual examination of the light curves and periodograms, there is no possibility of discovering anything new. For example, rotational modulation and flares in A stars would not have been noticed (Balona 2013). For this reason, visual inspection of the data is essential for further progress.

Using the SIMBAD database (Wenger et al. 2000), a master catalogue of about 684 000 stars brighter than magnitude 12.5 and with spectral types earlier than G0 was created. The catalogue includes the variability class if available, the effective temperature, luminosity, rotation period, spectral type and other useful parameters. The spectral type is important for ascertaining the variability class. It is also particularly useful because photometric effective temperature estimates are unreliable for B stars unless measurements in the U band are used (which is seldom the case). For example, the effective temperatures of B stars listed in the *Kepler* or *TESS* catalogues are not reliable. The master catalogue is not restricted to stars observed by *Kepler* or *TESS*.

As each *TESS* sector is released, stars in the bulk download file are matched with stars in the master catalogue and downloaded. The light curve from the FITS file is extracted automatically and stored in a database. If the star is already in the database, the additional data is appended to the existing light curve. Periodograms and extracted frequencies are calculated and form part of the database. Usually there are about 1000–2000 unclassified stars for each *TESS* release. Software tools (developed by the author) allow the periodogram and light curve to be displayed. Tools for smoothing the light curve, identifying harmonics and other useful functions are also included.

By visual inspection of the light curve and periodogram, the author has assigned a variability class to each star. In the few cases where a variability class is already known, there is good agreement. The task of visually classifying these stars typically takes two days. Changes are sometimes made to previously classified stars as more data become available. After each data release, the master catalogue is updated with the new classifications. The author has classified over 100 000 stars hotter than about 6000 K observed by *TESS* and *Kepler* in this way.

The variability classification follows that of the *General Catalogue of Variable Stars* (GCVS, Samus et al. 2017). A/F stars with rotational light modulation due to chemical

abundance spots (Ap stars) are classified as α^2 CVn (ACV) variables. Among the B stars these are known as SX Ari (SXARI) variables.

A new ROT class has been added to describe any star, not known to be chemically peculiar, in which the variability is suspected to be due to rotation. The criterion for ROT requires the presence of just a single, isolated frequency peak below 4d^{-1} or a peak and its harmonic. It is not always possible to distinguish rotation from binary effects, but to minimize such contamination, the ROT class is restricted to amplitudes below 10 millimag. The β Cep, SPB, Maia, δ Sct and γ Dor variables are typically multiperiodic and easily distinguished from the ROT stars.

A question arises as to what variability type must be assigned to a star which would be classified as roAp on the basis of the frequencies, but where the spectral type does not indicate chemical peculiarity. One could simply classify the star as a δ Sct. But what if the spectral type is incorrect and the star is indeed an Ap star? In that case one would lose the opportunity of detecting a new roAp variable. In these circumstances it is obviously important to make a note of these stars in some way. The solution that is adopted here is to label such stars as “roA” (ROA). This does not imply a new class of stellar variability, of course.

A separate catalogue was created containing individual T_{eff} measurements and literature references for as many as possible of the 684 000 stars in the master catalogue. This effective temperature catalogue presently contains over 185 000 individual T_{eff} measurements of about 101 500 stars, over and above the effective temperatures from the *Kepler* and *TESS* catalogues. The PASTEL catalogue (Soubiran et al. 2016) provided a very useful starting point for this compilation. Subsequent entries were made by searching the SIMBAD database.

For each entry in the effective temperature catalogue, the method used to derive T_{eff} was noted and assigned an index, t . If T_{eff} is derived from fitting a model atmosphere to the stellar spectrum, $t = 1$. If it is estimated from Strömgren, Geneva or other narrow-band photometry, $t = 2$. If T_{eff} is from the spectral energy distribution or similar method, $t = 3$. If it is from the *Kepler* or *TESS* catalogues $t = 4$. If it is estimated from the spectral type, $t = 5$. The adopted value of T_{eff} is the average of all the values with lowest t . Measurements with higher t values are ignored. From time to time, the master catalogue is updated with the adopted T_{eff} .

Photometric effective temperatures for Ap stars are unreliable because of line blanketing due to the spectral peculiarities. For this reason, it is best to use spectroscopic measurements ($t = 1$) whenever possible. Table 1 lists all individual T_{eff} values and references used to determine the adopted T_{eff} for stars listed in the Appendix. The table contains 574 entries for all 443 stars mentioned in this paper. For these stars, a thorough literature search was made to ensure that all available measurements are included.

Spectral types are mostly from the catalogue of Skiff (2014) supplemented by later publications when required. The calibration of Pecaut & Mamajek (2013) was used to estimate T_{eff} as a function of spectral type for those stars where the spectral type is the only available method of estimating T_{eff} ($t = 5$).

The stellar luminosity listed in the tables was estimated

Table 1. Catalogue of effective temperatures, T_{eff} , index, t , and literature reference. The full table is available in electronic form.

TIC	t	T_{eff}	Ref
2849758	4	9033	2018AJ...156..102S
3373254	5	7790	2013ApJS..208...9P
3542929	5	8500	2013ApJS..208...9P
3814749	2	7861	2020A&A...638A..76Q
3814749	2	8029	2019A&A...628A..94A
4463975	1	7629	2020ApJS..247...28H
5370150	2	6927	2019A&A...628A..94A

from *Gaia* EDR3 parallaxes (Gaia Collaboration et al. 2016, 2018) in conjunction with reddening obtained from a three-dimensional map by Gontcharov (2017) using the bolometric correction calibration by Pecaut & Mamajek (2013). From the error in the *Gaia* EDR3 parallax, the typical standard deviation in $\log(L/L_{\odot})$ is estimated to be about 0.05 dex, allowing for standard deviations of 0.01 mag in the apparent magnitude, 0.10 mag in visual extinction and 0.02 mag in the bolometric correction in addition to the parallax error. However, comparison between EDR3 and DR2 releases of the *Gaia* parallaxes suggests that the real error in luminosity is probably closer to 0.07 dex.

3 COMPARISON BETWEEN CHEMICALLY PECULIAR δ SCT AND ROAP STARS

We need to ask what characteristics are traditionally used in classifying a star as roAp. The general view is that roAp stars are simply Ap stars with high frequencies, but there is no consensus on the meaning of “high frequencies”. The lowest frequency in the group of recognized roAp stars (as listed in Smalley et al. 2015) is 61d^{-1} . It is reasonable to suppose, then, that “high frequencies” means any frequency higher than about 60d^{-1} .

Definition of a variability group should be based on physical considerations and not arbitrary choices. However, since no other definition has been proposed, it will be assumed that a star is roAp only if the pulsation frequency is higher than the hard limit of 60d^{-1} . Low-frequency peaks which can be attributed to rotation are often detected as well. Lower frequencies typical of γ Dor or δ Sct stars may co-exist with the high frequencies, in which case the star is given a hybrid classification, e.g. DSCT+ROAP.

Note that recently Holdsworth et al. (2021) admitted TIC 356088697, which has a single pulsation mode at 55.8d^{-1} , to the list of roAp stars. There is no real reason to query the lowering of the frequency limit, because there is no theory which provides a guide on the supposed frequency range in which roAp stars may pulsate. In fact, one might as well use any limit that feels right. This is clearly not a satisfactory situation.

Table A1 lists all known roAp stars, even those not observed by *TESS*. This is essentially the list in Smalley et al. (2015) supplemented by *TESS* discoveries by Cunha et al. (2019) and Balona et al. (2019) and, most recently, by Holdsworth et al. (2021). The sources of T_{eff} for these stars are listed in Table 1. The rotation periods in this and other tables are either those in the literature or updated by the author using the *TESS* light curves. The characteristic fre-

quency, ν , is the frequency of highest amplitude above 60 d^{-1} .

The Am (metallic-lined) stars are characterized by an under-abundance of Ca (and/or Sc) and/or an over-abundance of Fe and the iron-group elements. Unlike the Ap stars, the abundances of rare earth elements are normal and a global magnetic field is absent or very weak. The high metal abundance is thought to be a result of diffusion in the absence of a magnetic field (Michaud et al. 1976). As mentioned by Holdsworth et al. (2014), it is difficult to distinguish between Am and Ap stars at classification dispersion.

For this reason, and because Am stars are not known to pulsate with high frequencies, stars classified as Am are included in the tables as possibly mis-classified roAp stars. Rotational variables among Am stars are assigned the ROT class (not ACV). Some stars which are not known to be Ap, but which have been accepted in the literature as being roAp are also listed.

All known chemically peculiar stars observed by *TESS* were examined for pulsational variability. Quite a large number of δ Sct and γ Dor Ap stars were found (Table A2). These will be discussed separately below.

Fig. 1 shows the periodograms of a number of Ap δ Sct stars from Table A2 as well as roAp stars from Table A1. We note that there is no obvious frequency separation between stars which are classified as roAp, i.e. those with frequencies higher than 60 d^{-1} (right panel) and those of slightly lower frequencies (left panel), which we must presumably regard as Ap δ Sct stars. Note that the stars shown in the figure have single or isolated multiple high frequencies typical of roAp stars. The situation where a variability group is defined on the basis of an arbitrary frequency limit, but where no basis for such a limit exists, is clearly not satisfactory.

The main characteristic used to define roAp stars - that of high frequencies - can no longer be used. There is no frequency which marks an obvious lower limit to pulsations in Ap stars. Neither is there a discernible frequency gap between δ Sct and roAp classification. The argument that chemically peculiar stars do not pulsate cannot be used to justify the roAp class either.

4 NEW ROAP AND ROAP-LIKE STARS

Table A3 lists previously unreported *TESS* stars with effective temperatures $T_{\text{eff}} > 6000 \text{ K}$ in which at least one significant, independent frequency peak higher than 60 d^{-1} is present. The test for significance is based on the criterion that the peak amplitude must exceed the mean local noise level by a certain factor. It is not possible to directly calculate the false alarm probability in this way. The generally used criterion of $S/N > 4$ (Breger et al. 1993) is probably too optimistic (Baran et al. 2015; Baran & Koen 2021; Bowman & Michielsen 2021). Here we use the criterion $S/N > 4.7$, but of course there will always be uncertainty at low values of S/N .

Table A3 lists 19 known Ap stars with isolated high-frequency peaks or group of peaks higher than 60 d^{-1} which have not been previously reported. These would certainly be accepted as new stars of the roAp class. However, the majority of new pulsating stars in Table A3 are chemically normal. From this perspective, they are just δ Sct stars unless fur-

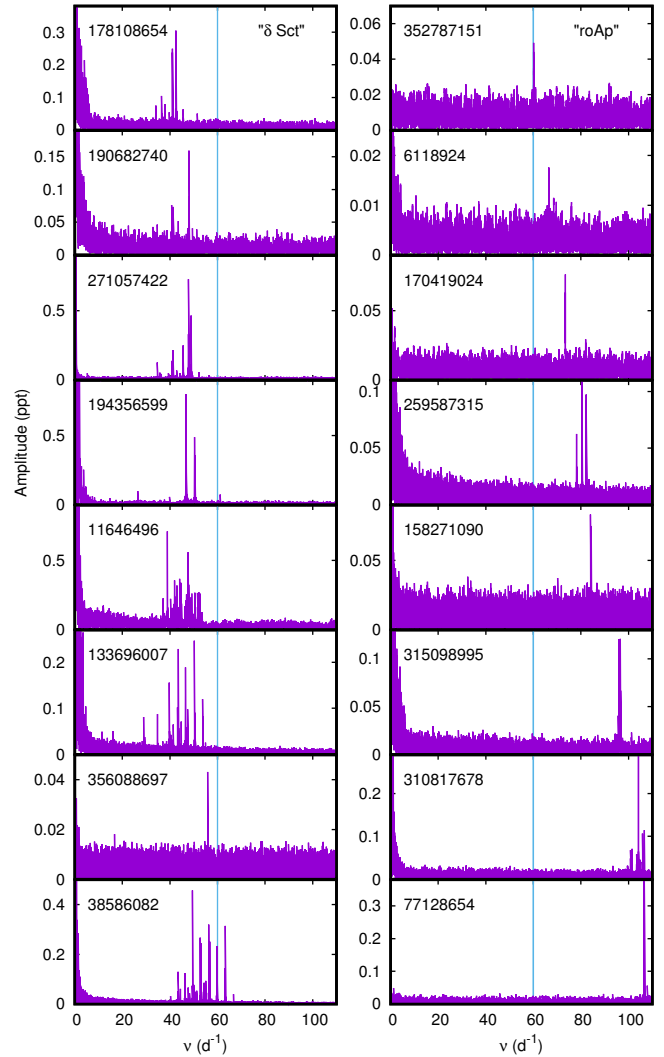


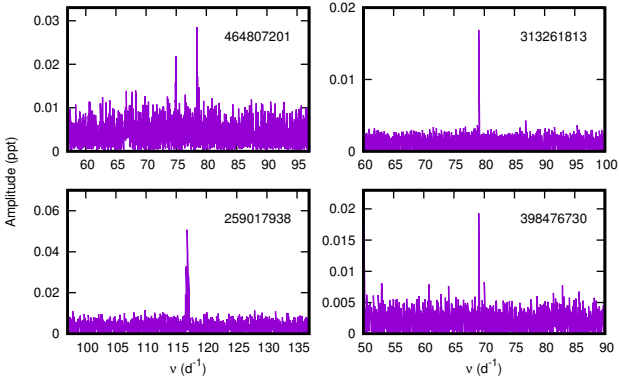
Figure 1. The periodograms of some Ap stars arranged in order of increasing frequency. The left panel shows what may be classified as δ Scuti variables while the right panel are all known roAp stars. As can be seen, there is no distinct separation between the two classes of Ap pulsating stars except for the artificial boundary at 60 d^{-1} (vertical line).

ther study shows that they are chemically peculiar. Labeling these roAp-like stars as “roAp” is not correct as there is no evidence that they are chemically peculiar. Classifying them as δ Sct would also not be correct because it is possible that some may turn out to be chemically peculiar. For this reason, the temporary label “roA” has been assigned to them. This does not signify a new class of variable star, but is simply a label to identify stars which cannot be properly classified until chemical peculiarity has been satisfactorily established or ruled out.

It would be expected that chemical peculiarities would be most easily detected in bright stars, yet the spectral classifications of many of the brightest roA stars do not mention chemical peculiarity. Four of these bright roA stars are listed in Table 2 and their periodograms shown in Fig. 2. As can be seen, these would certainly be classified as roAp stars. HD 119476 (TIC 313261813), for example, has been given

Table 2. Bright ROA stars discovered from *TESS* photometry.

TIC	Name	Var. Type	V	Sp. Type
313261813	HD 119476	GDOR+ROT+ROA	5.85	A1.5V
398476730	HD 104125	ROT+ROA	6.76	A2V
464807201	HD 29839	ROA+ROT	7.10	A1V
259017938	HD 210684	ROT+ROA+r	7.37	F0


Figure 2. Examples of bright stars, not known to be chemically peculiar, with high roAp-like frequencies.

spectral types in the range B9V–A2V by seven different authors (Skiff 2014) and in no case was chemical peculiarity identified.

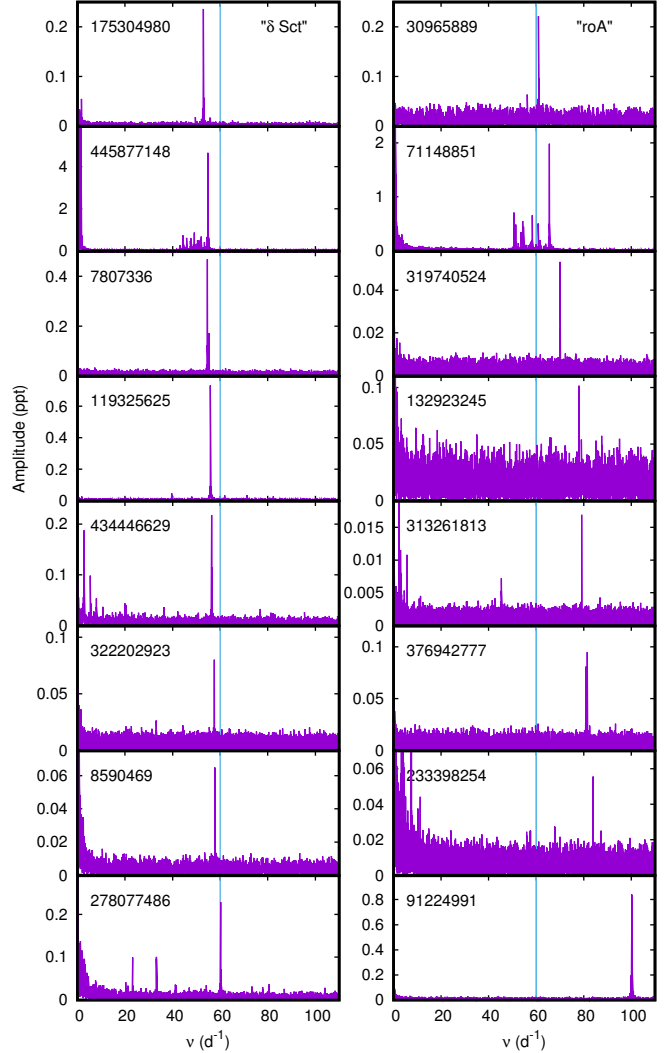
Fig. 3 shows periodograms of some ostensibly chemically normal roA stars arranged in order of increasing frequencies. We see that, as in the roAp stars, there is no separation between the roA and normal δ Scuti stars. What this figure also shows is that isolated frequency peaks, which are typical of roAp stars, are quite common among δ Sct stars as well (see Balona 2021b).

5 RADIAL ORDER AS A POSSIBLE DISCRIMINANT

It may perhaps be possible to discriminate between roAp stars and roAp-like δ Sct stars on the basis of pulsational radial order, as attempted in Balona et al. (2019). This is not likely to succeed because there is clearly a strong correlation between frequency and radial order. Furthermore, there is no physical basis why radial order should be important, but it is worth the attempt.

The radial order, n , associated with pulsation frequency for known roAp stars in Tables A1 was derived from the stellar parameters and pulsation models by Dziembowski (1977). Fig. 4 compares the radial order calculated for roAp stars (left panels) and for roA stars (right panels). The top panel shows the correlation between pulsation frequency and radial order. The scatter is due to stars in different stages of evolution. The middle panel shows n as a function of effective temperature. The bottom panel shows the pulsation frequency as a function effective temperature.

One might suppose, for example, that roAp pulsation might only occur above a certain radial order number. In that case the plot of radial order as a function of T_{eff} should show a hard boundary. As can be seen, this is not the case and the range in radial order is just as large as the range


Figure 3. The periodograms of some ostensibly chemically normal stars arranged in order of increasing frequency. The vertical line is the adopted limit of 60 d^{-1} . By analogy with the roAp stars, stars with at least one frequency higher than this limit are called “roA” stars, even though this distinction is purely arbitrary.

in frequency for both roAp and roA stars. Using the radial order offers no advantage over frequency as a means of distinguishing roAp/roA stars from δ Sct stars.

6 HYBRID δ SCT ROAP AND HIGH-FREQUENCY δ SCT STARS

Among the recognised roAp stars in Table A1, there are 10 δ Sct+roAp hybrids. A further three new δ Sct+roAp hybrids are listed in Table A3. It is, of course, possible that these stars are all multiple systems in which one star is δ Sct and the other a pure roAp star. This cannot be ruled out, but appears rather contrived. Recently, Murphy et al. (2020) have concluded that most of these δ Sct+roAp hybrids are not multiple stars.

There is a large number of chemically normal δ Sct variables with high frequencies. Whereas roAp and roA stars

Table 3. List of 617 new δ Sct stars with independent high frequencies exceeding 60 d^{-1} . The columns are the same as in Table A1. The full table is available in electronic form.

TIC	Name	Var Type	ν (d^{-1})	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
1221946	HD 30461	DSCT+ROA	62.016	7671	1.03		A2/3II
1404122	HD 80750	DSCT+ROA	60.152	8981	1.26		A0V
2004993	HD 34113	DSCT+ROT+ROA	60.265	8885	1.31	7.143	A0
3891160	HD 99120	DSCT+ROA	61.420	8614	1.21		A1V
4154746	HD 294001	DSCT+ROA	61.945	8490	1.12		A2
4202325	HD 35221	DSCT+ROA	71.942	8506	1.07		A2
4250763	HD 35318	DSCT+ROA	78.658	9414	1.40		A0

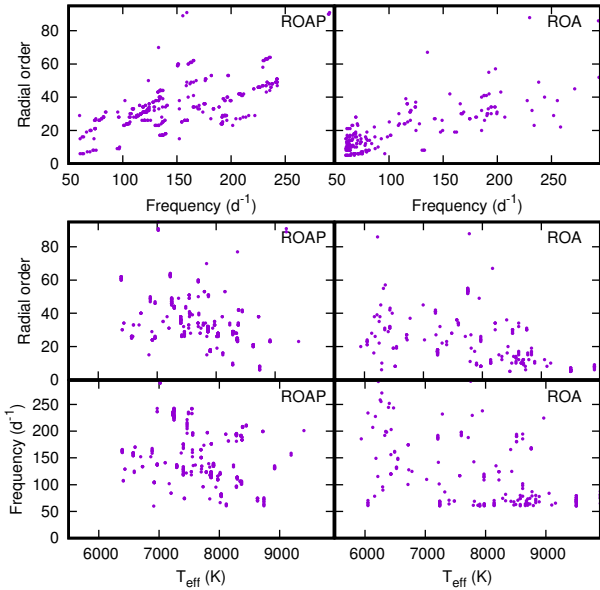


Figure 4. Top panel: the radial order, n , as a function of pulsation frequency. Middle panel: the radial order, n , as a function of effective temperature. Bottom panel: pulsation frequency as a function of effective temperature. The left panel shows stars recognised as roAp (Table A1). The right panel shows stars which have the same photometric characteristics as roAp stars but are not known to be chemically peculiar. These are presumably normal δ Sct stars, but here they are called roA stars because some might be misclassified Ap stars.

have only a few isolated high-frequency peaks, these high-frequency δ Sct stars have rich frequency spectra extending well into the roAp range. Most of the high frequencies are combinations and harmonics arising from non-linear interaction of low-frequency independent modes.

Independent frequencies may be determined by looking at all possible combinations of parent frequencies, ν_1 and ν_2 , such that $\nu = n_1\nu_1 + n_2\nu_2$, where n_1 and n_2 are positive or negative integers with $|n_1| \leq |n_{\text{max}}|$, $|n_2| \leq |n_{\text{max}}|$. The value of n_{max} should not be too large because for a sufficiently large value, almost any frequency can be described by a combination. It should also not be too low as to miss on a possible low-order interaction. As a compromise, $n_{\text{max}} = 7$ was chosen. In deciding whether a combination, ν , is significantly different from the observed frequency, ν_{obs} , the criterion $|\nu - \nu_{\text{obs}}| < 3\sigma$ was used, where σ is given by

$$\sigma^2 = \sigma_{\text{obs}}^2 + \sigma_1^2 + \sigma_2^2,$$

and σ_{obs} is the standard deviation of the observed frequency. The standard deviations of the parent frequencies are σ_1 and σ_2 .

There are at least 617 δ Sct stars with independent high frequencies in the roAp range. These are listed in Table 3. To distinguish them from other high-frequency δ Sct stars, they are labeled as δ Sct+roA. This is not meant to be a new class of variable, but just a convenient label.

It is not clear why δ Sct+roA stars should be driven by a different mechanism or how such stars are to be differentiated from δ Sct+roAp hybrids. In other words, chemically normal δ Sct stars with high frequencies can be considered to be in the same group as chemically peculiar δ Sct stars with high frequencies. There is no reason why the pulsation mechanism in these two groups should be different.

7 LOCATION OF STARS IN THE H-R DIAGRAM

High-frequency stellar pulsations are to be found in stars with high mean densities. As Fig. 5 shows, the δ Sct+roAp or δ Sct+roAp stars are found close to the zero-age main sequence where the mean densities are the largest. One may expect stars with lower frequencies to be more evolved because they would be less dense and have larger radii. To show this, δ Sct with frequencies higher than 50 d^{-1} but not higher than 60 d^{-1} (labeled as DSCTHF in the figure), are, on average, slightly more evolved, as expected.

Most roAp and roA stars populate the cooler half of the δ Sct instability region. There are a significant number of roA stars cooler than the red edge of the δ Sct instability strip defined by the *Kepler* δ Sct stars. The pulsations in these cool roA stars cannot be mistaken for solar-like oscillations because the typical Gaussian envelope of peak amplitudes is not seen. Furthermore, the stars do not obey the scaling law for solar-like oscillations (Kjeldsen & Bedding 1995). However, there are indications that the δ Sct instability region defined by *TESS* stars is extended towards cooler stars compared to the *Kepler* instability region shown in Fig. 5. This may be a result of metallicity differences between the *Kepler* and *TESS* stars. Most likely these cool roA stars are simply δ Sct stars in which isolated high frequencies in the roAp range are selected.

8 Ap STARS WITH δ SCUTI PULSATIONS

Saio (2005) performed a non-adiabatic analysis of axisymmetric nonradial pulsations in the presence of a dipole mag-

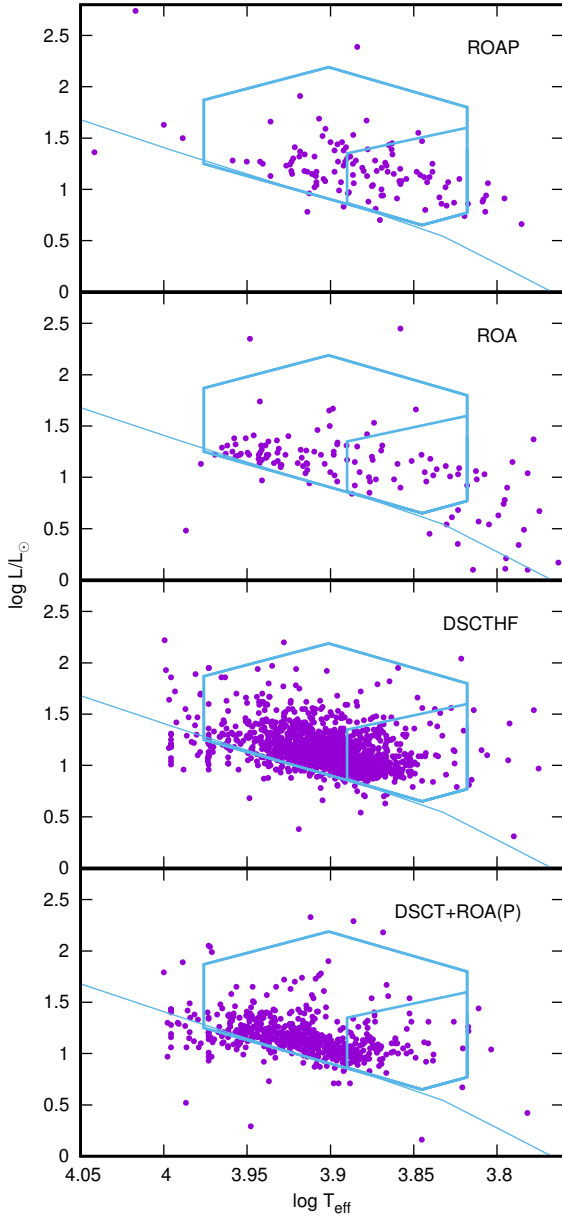


Figure 5. The top two panels show the locations of the roAp and roA stars in the theoretical H-R diagram. The third panel shows δ Sct stars with frequency peaks $50 < \nu < 60 \text{ d}^{-1}$ (high-frequency δ Sct stars, DSCTHF). The bottom panel shows δ Sct stars with at least one independent frequency $\nu > 60 \text{ d}^{-1}$. The solid line is the zero-age main sequence for solar abundance models by Bertelli et al. (2008). The polygons are the approximate areas where most δ Scuti and γ Dor stars are found (Balona 2018).

netic field for a model with $M = 1.9 M_{\odot}$ in which convection was suppressed in the stellar envelope. It was found that δ Sct pulsations are damped if the polar field strength is larger than about 1 kG. However, high-order p modes with frequencies corresponding to roAp stars driven by the κ mechanism in the H α ionization zone remain overstable, even in the presence of a strong magnetic field. This analysis suggests that roAp pulsations should not co-exist with δ Sct pulsations in Ap stars unless the magnetic field strength is lower than about 1 kG.

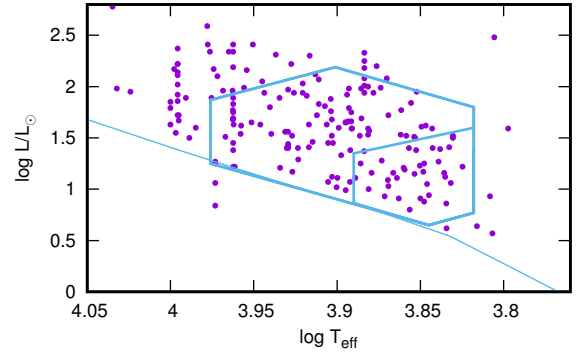


Figure 6. Location of chemically peculiar δ Sct stars of Table A2 in the theoretical H-R diagram.

More recent calculations by Murphy et al. (2020) indicate that the fundamental mode can be excited even in the presence of a magnetic field as strong as 4 kG, but high radial order g modes typical of γ Dor pulsations are strongly suppressed. If this prediction is correct, there should not be many Ap stars with low-frequency γ Dor pulsations. There are 199 Ap/Fp stars in which δ Sct or γ Dor pulsations are present (Table A2). Most of the Ap δ Sct stars have multiple low-frequency peaks indicative of high radial order g modes, suggesting a possible problem in the models used by Murphy et al. (2020).

The prevailing view is that δ Sct pulsations are not found, or are very rare, among Ap stars. As Table A2 shows, this is not the case. *Kepler* observations of TIC 26418690 (KIC 11296437), the star discussed by Murphy et al. (2020), show that it is a δ Sct+roAp star, but the δ Sct peaks have too low an amplitude to be seen in *TESS* data. Murphy et al. (2020) argue that it is not a binary and that the δ Sct and roAp pulsations originate in the same star.

It is interesting to note that the number of δ Sct+roAp stars relative to Ap δ Sct stars (13/199 or about 7 percent), is about the same as the number of δ Sct+roA stars relative to non-Ap δ Sct stars (617/8370 or 7 percent).

To compare the relative number of pulsating Ap/Fp stars with those of normal A/F stars, only main-sequence stars brighter than 10-th magnitude and with $6000 < T_{\text{eff}} < 9000 \text{ K}$ were selected. The magnitude limit ensures that the sample is fairly complete. With these restrictions, there are 37348 stars observed by *TESS* of which 7104 are classified as δ Sct or γ Dor. Thus about 19 percent of all main sequence stars in this temperature range are pulsating δ Sct/ γ Dor variables.

In the same effective temperature and magnitude ranges, there are 875 Ap/Fp stars observed by *TESS* of which 89 are δ Sct or γ Dor stars. Among Ap/Fp stars, about 10 percent pulsate as δ Sct or γ Dor. In the the same T_{eff} and magnitude ranges, there are 60 *TESS* roAp stars. Therefore the fraction of pulsating stars among the chemically peculiar stars is $(89+60)/875$ or about 17 percent. One may conclude that the fraction of pulsating Ap stars is about the same as the fraction of pulsating chemically normal stars. However, there is a very clear tendency for higher frequencies among Ap stars.

Fig. 6 shows the stars listed in Table A2 in the theoretical H-R diagram. It is clear that the chemically peculiar

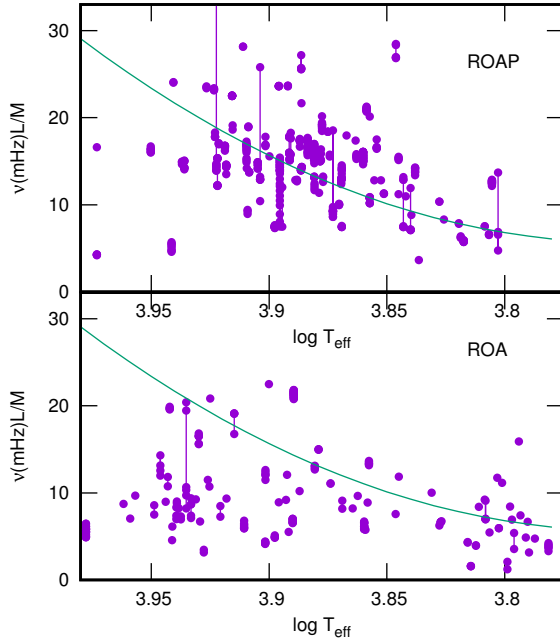


Figure 7. The location of the roAp and roA stars in the $\log T_{\text{eff}} - \nu L/M$ plane where ν is the frequency in mHz and L , M is the luminosity and mass in solar units. Different frequencies in the same star are connected by a vertical line (harmonics ignored). The solid curve is the approximate acoustic critical frequency from models.

δ Sct stars occupy the same instability region as chemically normal δ Sct stars.

9 CRITICAL FREQUENCIES

It has been known for a long time that the pulsation frequencies in a significant number of roAp stars exceed the acoustic critical frequency, ν_{crit} . This is the frequency beyond which the pulsational acoustic waves are no longer reflected in the atmosphere. Modes with $\nu > \nu_{\text{crit}}$ manifest as running waves, leading to energy loss and damping of pulsational driving.

As pointed out by Saio (2014), the critical frequency is best shown in the $\log T_{\text{eff}} - \nu L/M$ plane where ν is the frequency in mHz and L and M are the luminosity and mass in solar units. Fig. 7 shows the location of the roAp and roA stars in this diagram. The calculated critical frequency is adapted from Saio (2014) and Audard et al. (1998). Note that the frequencies in about half the roAp stars exceed the critical acoustic frequency. However, for most of the roA stars the pulsation frequency is below critical.

It is not clear if this result is significant owing to uncertainties in the stellar parameters as well as uncertainties in the atmospheric models used to estimate ν_{crit} . In any case, it is not clear whether the atmospheric structure in highly magnetic stars is the same as in non-magnetic stars. Perhaps the difference can be reconciled in this way and that ν_{crit} is underestimated in the Ap stars. If Ap stars do have systematically higher critical frequencies than normal stars, it might explain why high frequencies are more common among Ap stars.

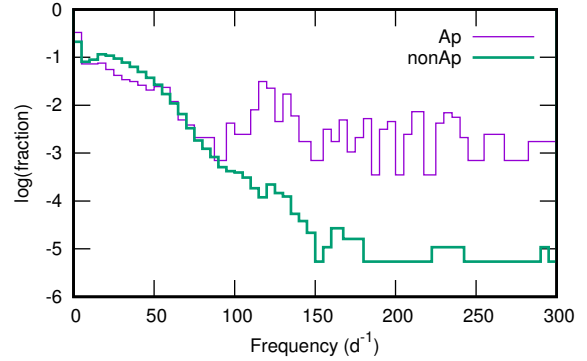


Figure 8. The frequency distribution for δ Sct+ γ Dor+roA stars (thick (green) line) and for Ap δ Sct+ γ Dor+roAp stars (thin violet) line. This is the fraction of independent frequencies within a frequency interval of 5 d^{-1} . All frequency peaks with $S/N > 4.7$ are given the same weight (amplitude ignored).

10 CONCLUSIONS

It is generally believed that chemically peculiar Ap/Fp stars do not pulsate as δ Sct or γ Dor variables. In this paper we have examined 1978 known Ap/Fp stars observed by *TESS* and found that not only do some pulsate as roAp stars, but 199 pulsate as δ Sct or γ Dor stars (Table A2). Furthermore, as Fig. 1 shows, there is no separation in frequency between these chemically peculiar δ Sct stars and the roAp stars. If this were known when the roAp stars were first discovered, there would have been no motivation for creating a separate roAp class at all.

The roAp class, in any case, has never been properly defined. In this paper a hard frequency limit of 60 d^{-1} is used to separate δ Sct from “roAp” stars. This is a purely arbitrary figure. No actual frequency or radial order limit can be established.

The *TESS* observations have shown that isolated high frequencies characteristic of roAp stars can be found in stars which have not been noted as chemically peculiar. In this paper, 103 new stars of this kind are presented (Table A3), in addition to those previously discovered (Cunha et al. 2019; Balona et al. 2019). Some, but not all, of ostensibly non-peculiar stars with isolated frequency peaks in the roAp range have been subsequently found to be chemically peculiar (Holdsworth et al. 2021).

TESS observations of δ Sct stars show that many pulsate with frequencies in the roAp range. The high frequencies in most of these stars are due to combinations or harmonics. An analysis of a large number of δ Sct stars resulted in the discovery of at least 617 high-frequency δ Sct stars with independent pulsation frequencies in the roAp range (Table 3).

All the reasons which motivated the creation of a new class of variable, the roAp stars, have disappeared. It is recommended that the term “roAp” be avoided and that these be considered as normal δ Sct stars. There is no reason to suppose that the high frequencies in normal δ Sct stars are driven by a different mechanism than in the “roAp” stars. The need for the mechanism described by Balmforth et al. (2001) falls away.

The strong magnetic field in Ap stars does, however, affect pulsations in some stars. This is evident in about one-

third of the roAp stars in which equidistant frequency peaks separated by the rotational frequency are seen. It is likely that the strong magnetic field modifies the atmospheric structure so that the sound speed varies in conjunction with the magnetic field over the surface of the star. Under some circumstances, the pulsational amplitude may vary significantly across the surface. This will only be noticeable in the highest frequencies where the pulsational wavelength is comparable with the atmospheric scale height. This explains, in a natural way, why the pulsation axis appears to be aligned with the magnetic axis in some roAp stars (the oblique pulsator model, Kurtz 1982; Kurtz & Shibahashi 1986).

It has been known for some time that the spectroscopic line profile variability in roAp stars is characterized by blue-to-red moving features (e.g. Kochukhov & Ryabchikova 2001a,b). This behaviour is common in many rotating nonradial pulsators and indicates non-axisymmetric pulsations. However, this is inexplicable in the framework of the standard oblique pulsator model of slowly-rotating roAp stars which demands axisymmetric modes. Why only axisymmetric modes seem to be selected is not known. (Kochukhov et al. 2007) suggests that the modes can still be axisymmetric if the line width varies with height in the atmosphere. In the context proposed here, where the pulsation amplitude varies with magnetic field strength because of changes in sound speed, there is no need to assume axisymmetric modes in the oblique pulsator model. Naturally, the pulsation will be magnetohydrodynamic in nature and not purely acoustic.

Saio (2005) and Murphy et al. (2020) discuss pulsation in a model of a star in which convection is suppressed by a strong magnetic field. These calculations predict that high-order g modes typical of γ Dor pulsations are strongly suppressed in Ap stars. In fact, most of the 199 pulsating Ap stars observed by *TESS* are either γ Dor stars (frequencies not exceeding 5 d^{-1}) or contain multiple low frequencies in the γ Dor range if they are δ Sct variables. Evidently, the models of Saio (2005) and Murphy et al. (2020), as they stand, are not supported by observations.

Fig. 8 shows the distribution of extracted frequencies in 12544 non-Ap and 255 pulsating Ap stars. Note that this is not the distribution of stars. Combination frequencies and harmonics have been excluded. It can be seen that in both cases there is a continuous distribution with a long high-frequency tail. The incidence of high frequencies is clearly much higher in “roAp” than in normal δ Sct stars. This does constitute a distinct difference, but it is not directly related to the pulsation mechanism. It would appear that for some reason high frequencies are preferentially selected in stars with strong magnetic fields.

Unfortunately, we have no idea what drives high frequencies in δ Sct stars, both chemically normal and chemically peculiar. As already mentioned, Xiong et al. (2016) have shown that it is possible to drive high frequencies in models of normal intermediate mass stars, but only for stars in a small region of the instability strip. Without a model, further progress in understanding the δ Sct stars cannot be made.

One of the most striking and puzzling results of the *Kepler* and *TESS* missions is that the distribution of frequency peaks in δ Sct stars is completely unpredictable. Two stars with the same effective temperature, luminosity, metallicity

and rotational velocity should have nearly the same observed frequencies. This turns out not to be the case: the frequencies that are observed may be completely different in the two stars (Balona 2021b). It seems that a highly nonlinear mode selection process is active.

There is a further discovery which might impact on the driving of the oscillations. *Kepler* and *TESS* light curves indicate that the light from A and B stars are modulated by rotation (Balona 2019; Balona & Ozuyar 2021). Flares are sometimes seen in A and late B stars (Balona 2012, 2013, 2015, 2021a). At this stage, there is no model which can account for these phenomena in hot stars. It is also possible that accretion of interstellar material may affect the outer layers of A stars, as suggested by Böhm-Vitense (2006).

Current pulsation models assume that the outer layers are static and devoid of magnetic fields. The treatment of the stellar outer layers in current models is therefore incomplete. This may have an impact on the predicted pulsational stability and may play an important role in mode selection. For further progress, it is essential to study the atmospheres of A and B stars in order to understand the nature of the rotational modulation and to detect possible mass motions. Such a study may lead to pulsation models which better reproduce the observations.

DATA AVAILABILITY

The data underlying this article are available in the article.

ACKNOWLEDGMENTS

I thank the National Research Foundation of South Africa for financial support and Dr Gerald Handler for useful comments.

This paper includes data collected by the *TESS* mission. Funding for the *TESS* mission is provided by the NASA Explorer Program. Funding for the *TESS* Asteroseismic Science Operations Centre is provided by the Danish National Research Foundation (Grant agreement no.: DNR106), ESA PRODEX (PEA 4000119301) and Stellar Astrophysics Centre (SAC) at Aarhus University. We thank the *TESS* and TASC/TASOC teams for their support of the present work.

This work has made use of data from the European Space Agency (ESA) mission Gaia (<https://www.cosmos.esa.int/gaia>), processed by the Gaia Data Processing and Analysis Consortium (DPAC, <https://www.cosmos.esa.int/web/gaia/dpac/consortium>). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. This research has made use of the VizieR catalogue access tool, CDS, Strasbourg, France (DOI: 10.26093/cds/vizieR). The original description of the VizieR service was published in A&AS 143, 23.

The data presented in this paper were obtained from the Mikulski Archive for Space Telescopes (MAST). STScI is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS5-2655.

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APPENDIX

Table A1. List of known roAp or roA stars. The TIC number, name, variability type and characteristic pulsation frequency is given, followed by the effective temperature and luminosity. Where available, the rotation period is given. The last column is the spectral type. A colon denotes uncertain values. The variability class is expanded to include the following: r - rotational sidelobes present; s - variable amplitudes and/or frequencies; 2h,3h - highest harmonic present; l - low frequencies present. A row in italics indicates that the star was not observed by *TESS*. The variability type in square brackets means that the high frequencies are not detected in the *TESS* light curve

TIC	Name	Var Type	ν (d ⁻¹)	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
3814749	HD 3748	ROT+ROA	238.205	7945	1.05	1.689	A5
6118924	HD 116114	ROAP	66.461	7817	1.46		F0VpSrCrEu
12968953	HD 217704	ROAP	115.586	7669	1.28		ApSrEuCr*
16596302	HD 52524	ROT+ROA:	74.156	8733	0.97	2.532	A0
17676722	HD 63773	ACV+ROAP+r	167.749	8754	1.27	1.599	ApSrEuCr*
22113439	TYC 2612-1843-1	ACV+ROAP	62.639	7900	1.38	2.119	A7m:
22132451	2MASS J17584421+3458339	ACV+ROAP	71.280	7700	1.14	0.860	A7m:
23671771	HD 70664	ROT+ROA	293.202	6223	0.90	6.135	F5
24344701	HD 34282	ROA	75.412	9500	1.13		A0.5Vb(shell)
26418690	KIC 11296437	ACV+DSCT+ROAP+r	121.800	7052	1.17		Ap
26749633	TYC 3560-2018-1	[ROAP]	118.603	6898	1.17		F2V(Sr)
27395746	KIC 11409673	ACV+[ROAP]+r	216.080	7490	1.04	12.214	Ap
33601621	HD 42659	ACV+ROAP+r	150.990	7698	1.53	2.659	A3SrCrEu
34783979	TYC 1787-186-1	ROA:	233.958	6047	0.10		
35905913	HD 132205	ACV+[ROAP]	201.658	8631	1.13	7.535	A2EuSrCr
41259805	HD 43226	ACV+ROAP+r	199.673	8721	1.25	1.714	ApSrEu(Cr)*
44827786	HD 150562	ROAP	133.661	6390	1.06		A5:EuSi??
49332521	HD 119027	ROAP	167.790	6750	1.07		ApSrEuCr:
49818005	HD 19687	ROAP	141.860	7213	1.20		FpSrEu(Cr)*
<i>58106971</i>	<i>TYC 2269-996-1</i>	<i>DSCT+ROA</i>	<i>79.130</i>	<i>6650</i>	<i>1.09</i>		<i>A0V</i>
61811148	TYC 7926-99-1	DSCT+ACV+ROAP	164.475	7800	0.83	0.848	A7m
69855370	HD 213637	ROAP	125.479	6414	0.78		Ap:Eu:Sr:Cr:
71134596	HD 28548	DSCT+ROA	65.245	8200	1.07		A0IV/V λ Boo
<i>72428505</i>	<i>HD 195061</i>	<i>DSCT+ROAP</i>	<i>128.860</i>	<i>8000</i>	<i>1.08</i>		<i>A0Vm</i>
77128654	HD 97127	ROAP	106.618	6407	0.94		F3pSrEu(Cr)
92350273	CD-33 15279	ROT+ROA	244.814	7003	1.22	6.622	F5
93522454	HD 143487	[ROAP]	149.472	7866	1.44		A3SrEuCr?
96315731	HD 51203	ACV+ROAP	165.259	7693	1.06	6.674	ApSrEuCr
96855460	HD 185256	ACV:+ROAP	140.628	6646	1.10	26.329	ApSrEu:Cr:
98728812	HD 18407	ROA	65.301	9159	1.31		A0V
<i>100196783</i>	<i>HD 193756</i>	<i>ROAP</i>	<i>111.024</i>	<i>7545</i>	<i>1.39</i>		<i>A9SrCrEu</i>
100775380	HD 39763	GDOR+ROA	68.860	8420	1.4:		A1V
118247716	HD 12519	ROAP	170.288	7403	1.00		A4pSrEuCr
119327278	HD 45698	ACV+ROAP+r	210.614	8445	1.23	1.085	A2SrEu
123231021	KIC 7582608	GDOR+ACV:+ROAP	181.699	7801	1.38	9.906	A7pEuCr
125297016	HD 69013	[ROAP]	128.304	6951	1.07		A2SrEu
<i>128821559</i>	<i>TYC 3218-888-2</i>	<i>DSCT+ROAP</i>	<i>75.540</i>	<i>8100</i>	<i>1.07</i>		<i>A3m</i>
136842396	HD 9289	ACV+ROAP+r	136.953	7900	1.17	8.566	A3SrEuCr
137797293	TYC 6390-339-1	DSCT+ROA	66.960	8200	1.13		A3
<i>138093523</i>	<i>TYC 3139-1403-1</i>	<i>DSCT+ROA</i>	<i>129.030</i>	<i>7274</i>	<i>0.98</i>		
139191168	HD 217522	ROAP+s	104.179	6834	0.92		A5SrEuCr
146715928	HD 92499	ROAP	136.703	8231	1.34		A2SrEuCr
152808505	HD 216641	GDOR:+ROAP	119.210	6430	0.9:		FpEuCr*
<i>153101639</i>	<i>2MASS J16400299-0737293</i>	<i>ACV+ROAP+r+3h</i>	<i>151.891</i>	<i>7500</i>	<i>1.03</i>	<i>3.675</i>	<i>A7VpSrEu(Cr)</i>
156886111	HD 47284	ACV+ROAP+r	112.406	8294	1.32	6.856	ApSrEuCr*
<i>158009180</i>	<i>TYC 5762-828-1</i>	<i>DSCT+ROA</i>	<i>212.660</i>	<i>6000</i>	<i>1.37</i>		<i>F8</i>
158216369	KIC 7018170	ACV+[ROAP]+r	168.074	6927	1.12	72.747	Ap
158271090	TYC 3545-2756-1	ACV+ROAP+r+2h	84.033	7293	1.45	5.685	Ap
158275114	KIC 8677585	GDOR+ROAP+2h+s	136.975	7468	1.28		A5EuCr
159392323	TYC 3547-2692-1	ROAP	128.752	6436	0.88		F3pSrEuCr
163587609	HD 101065	ROAP+s	118.617	6246	0.91		F0?V? pec
167695608	TYC 8912-1407-1	ROAP+s	132.365	7292	1.34		F0pSrEu(Cr)
168383678	HD 96237	ACV:+[ROAP]	103.680	8119	1.32	22.842	A4SrEuCr
169078762	HD 225914	ACV:+[ROAP]+r	61.448	8070	1.69	5.242	A5VpSrCrEu
170419024	HD 151860	ROAP	73.452	7339	1.17		ApSrEuCr:
170586794	HD 107619	ACV:+ROAP	152.194	6695	0.87	10.299	F5pEuCr*
171988782	HD 258048	ROAP	169.537	6600	0.74		F4pEuCr(Sr)

Table A1 – *continued*

TIC	Name	Var Type	ν (d ⁻¹)	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
173372645	HD 154708	ACV+[ROAP]	180.403	6812	0.86	5.366	A2SrEuCr
174475885	HD 61622	SXARI+ROAP:	229.188	11763	2.09	0.852	B9Si
176516923	HD 38823	ACV+ROAP	165.285	7551	1.13	8.572	A5SrEuCr*
176941102	HD 106563	DSCT+ROAP	65.460	8100	1.17		A3m:
178575480	HD 55852	ACV+ROAP:	207.181	8018	1.10	4.775	A0SrEuCr
179193226	HD 122570	DSCT+ROA	99.120	7550	1.42		A3/5III:
189996908	HD 75445	ROAP	159.116	7364	1.26		ApSrEuCr:
203817942	HD 147911	DSCT+ROAP:	68.520	8200	0.78		A0Vm
206477008	HD 24426	GDOR+ROA:	171.795	6765	0.54		F5V
211404370	HD 203932	ACV:+ROAP+r+s	242.330	7350	1.23	6.419	A5SrEu
217302172	HD 156623	DSCT+ROA	63.700	9040	1.21		A1V
220073982	HD 288081	ROT+ROA+r:	73.103	8832	1.41	0.307	A2
224284872	TYC 577-322-1	DSCT+ROA	60.47	9700	0.48		A3
237336864	HD 218495	ACV+ROAP+r+s	195.370	8120	1.02	4.200	A2EuSr
258178726	BD+25 3139	DSCT+ROA	105.120	7100	1.16		F0
259587315	HD 30849	ACV+ROAP+r	80.444	8030	1.52	15.866	ApSrCrEu
260751881	TYC 9131-119-1	ACV+ROA+2h	92.753	8050	1.22	1.197	A5m:
262590112	TYC 577-322-1	DSCT+ROA	60.420	8276	1.27		A5
264509538	KIC 10685175	ACV+ROAP+r	191.514	8179	0.96	3.103	Ap
268460597	HD 52264	ACV+ROAP:	192.139	10400	2.74	7.817	B0Si
268751602	HD 12932	ROAP+2h	124.096	7536	0.88		ApSrEuCr
272598185	KIC 10483436	ACV+[ROAP]+r	116.899	7329	1.43	4.304	kA5hA7mA9SrCrEu
273777265	KIC 6631188	ACV+ROAP+r	129.038	7700	1.25	2.516	Ap
279485093	HD 24712	ACV+ROAP+r	235.064	7246	0.91	12.681	kA5mF0V?Sr
280198016	HD 83368	ACV+ROAP+r+4h+s	123.025	7784	1.27	2.852	A8VrCrEu
284377321	HD 138334	ROT+ROA	86.376	7869	1.32	1.523	A0V
286992225	TYC 2553-480-1	ROAP	235.540	7387	0.94		A9pSrEu
293265536	TYC 4-562-1	ROAP	150.250	7300	1.39		A9pSrEu(Cr)
294266638	BD-19 2553	ROT+ROAP	140.730	7212	1.05		ApSrEu*
294769049	HD 161423	ACV+[ROAP]	195.303	8385	1.18	10.458	ApSrEu(Cr)
299000970	HD 176232	ACV+ROAP	125.099	7775	1.41	6.050	A4pSrEuMn
302602874	TYC 2488-1241-1	ACV+ROAP+r	197.262	7800	1.23	3.093	A6pSrEu
308307808	CD-60 2021	DSCT+ROA	63.293	8310	1.14		A3:
310817678	HD 88507	ACV+ROAP+r	104.136	8364	1.30	2.750	ApSrEuCr:
315098995	HD 84041	ACV+ROAP+s	95.989	7730	1.32	3.696	ApSrEuCr
317719322	HD 40098	DSCT+ROA	60.186	8990	1.23		A2/3V
318007796	HD 190290	ACV+ROAP+r	196.330	6776	1.02	4.041	A0EuSr
322732889	HD 99563	ACV+ROAP+r+2h	134.238	9095	1.28	2.900	F0Sr
326185137	HD 6532	ACV+ROAP+r+2h	207.032	8383	1.27	1.945	ApSrCrEu
335303863	HD 137949	ACV+ROAP+4h	174.079	8121	1.14	7.200	kA9hA5pSrCrEu
340006157	HD 60435	ACV+ROAP+r+2h+s	116.857	7860	1.27	7.679	A3SrEu
342624968	HD 207561	[ROAP:] +s	240.000	7200	1.08		F0IIIIm
348717688	HD 19918	ROAP+2h+s	130.475	7400	1.21		ApSrEuCr
349945078	HD 57040	ACV+ROAP+r	183.719	8375	1.15	13.473	A2EuCr
350146296	HD 63087	ACV+ROAP+r	304.404	7753	0.96	2.664	F0pEuCr
354619745	HD 201601	ACV+ROAP+s	117.901	7588	1.18	1785.700	A7pSrCrFe
363716787	HD 161459	ACV+ROAP	119.838	6979	1.12	5.974	A2EuSrCr
368866492	HD 166473	ACV:+ROAP	163.460	7451	1.18	3.48:	A5SrEuCr
369845536	UCAC2 13032830	ACV+ROAP+r	176.391	6900	1.25	9.529	F2(p Cr)
371800781	TYC 9311-73-1	ACV:+ROAP	62.540	8200	1.17	0.869	A4m
375937924	TYC 525-2319-1	DSCT+ROAP	104.860	7000	1.47		A3m:
380651050	HD 176384	ROT+ROA	162.234	6490	0.98	4.184	F0/2V
380729861	TYC 297-328-1	DSCT+ROAP	68.990	7850	3.91		A4m
383521659	HD 137909	ACV+ROAP	83.549	7997	1.59	18.487	kA8hF0pSrCrEu
387115314	CPD-77 1337	ROT+ROA	117.178	7679	1.15	5.264	A5
394124612	HD 218994	DSCT+ACV+ROAP	98.870	5096	1.46	11.647	A3Sr
394272819	HD 115226	ACV+ROAP+r	132.590	8916	1.27	2.989	ApSrEu:
396749572	2MASS J21553126+0849170	DSCT+ROA	61.340	7915	1.67		A3
399665133	BD+06 763	ROT+ROA	71.101	8532	1.28	0.447	A2
402546736	HD 128898	ACV+ROAP+r	210.995	7463	0.81	4.480	A7VpSrCrEu
407661867	HD 37584	ROT+ROA	64.063	8656	1.22	0.562	A3V

Table A1 – continued

TIC	Name	Var Type	ν (d ⁻¹)	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
407929868	HD 24355	ACV+ROAP+r	224.294	8235	1.18	27.916	A5VpSrEu
411247704	HD 196470	ROAP	133.402	7279	1.15		A2SrEu
413938178	HD 148593	ROAP	134.784	7763	1.30		A2Sr
420687462	HD 122970	ACV+ROAP+s	129.816	6766	0.84	3.877	F0CrEuSr
431380369	HD 20880	ACV+ROAP+r+s	74.350	8629	1.66	5.197	ApSr(EuCr)
432223926	HD 134214	ACV+ROAP+2h+s	254.621	7403	0.94	248.000	F2VpSrCrEu
434449811	HD 80316	ACV+ROAP+r	194.552	8106	1.13	2.088	ApSr(Eu?)
439399707	HD 225186	ROT+ROA	60.079	7900	1.02	1.661	A3V
445543326	HD 12098	ACV+ROAP+r	187.808	7152	1.10	5.460	F0Eu
465996299	HD 177765	ROAP	60.998	7557	1.67		A5SrEuCr
466260580	TYC 9087-1516-1	ROT+ROAP	115.802	6099	0.66	0.695	ApEuCr*
468912168	HD 26400	DSCT+ROAP	68.223	8150	1.15		A3m:
469246567	HD 86181	ACV+ROAP+r	232.770	7222	1.08	2.051	F0Sr

Table A2. Chemically peculiar stars known to be δ Scuti or γ Doradus variables. The columns are the same as Table A1 (the characteristic frequency is omitted).

TIC	Name	Var Type	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
2849758	HD 243007	DSCT	9033	1.99		A1Si
3373254	HD 244248	DSCT	7790	1.75		A5SiSr
3542929	HD 244372	DSCT	8500	1.40		A1Sr
9211526	HD 221226	GDOR	6840	1.12		F3Sr?
9668192	<i>HD 143517</i>	<i>DSCT</i>	<i>9150</i>	<i>1.22</i>		<i>A3Sr</i>
11646496	HD 8717	DSCT+ACV	7245	1.21	2.178	A5pCr
17233245	HD 27429	DSCT	6831	0.86		F2Vn(Cr)
19924794	<i>HD 123255</i>	<i>DSCT+ACV</i>	<i>6903</i>	<i>1.27</i>	<i>0.839</i>	<i>F0IV(Cr)</i>
21073591	BD+29 3448	DSCT	7611	1.59		F0pSr
24693528	HD 14944	GDOR	7522	2.20		ApEuCr:
26418690	KIC 11296437	ACV+DSCT+ROAP+r	7052	1.17	7.124	Ap
27962331	HD 211074	DSCTHF	7939	1.11		A5pSr(Eu)
29205693	HD 87679	DSCT	7080	0.91		A9IV(pSr)
30481397	TYC 8152-1872-1	DSCT	7948	1.02		A2pSrCrEu
30718811	HD 33043	GDOR+ACV	7234	1.19	0.978	F0VSr
38136475	HD 210424	MAIA	13062	2.56		B6Si
31870361	HD 22488	DSCT	7219	1.52		A3SrEuCr
38586082	HD 27463	ACV+DSCT	8700	1.54	2.834	ApEuCrSr:
39818458	HD 40759	EA+DSCT	8785	1.94		A0CrEu
40564267	HD 184471	DSCT	10000	1.85		A9SrCrEu
45803944	HD 42509	SPB	10139	2.85		B9.5VSi:
46041110	HD 125081	DSCT	6803	1.41		F3SrCrEu
47557667	<i>HD 129052</i>	<i>DSCT</i>	<i>9400</i>	<i>1.25</i>		<i>A2SrEu?</i>
48330947	HD 85766	DSCT	7404	1.09		ApSi:Cr:
49673974	<i>HD 220556</i>	<i>DSCT</i>	<i>9400</i>	<i>1.27</i>		<i>A2SrEuCr</i>
50835993	HD 71434	DSCT	7653	1.37		A2EuCrSi?
57965241	HD 168314	DSCT+ACV	9900	1.92	7.337	A0SiEuCr
61004258	HD 81009	DSCT	9164	1.63		F1pSiSrCrEu
63671517	HD 53021	DSCT+ACV	7650	1.94	3.757	B9Si
67467015	BD+36 363	GDOR	6679	1.22		F3:IVSr:
67668604	HD 7898	DSCT	7312	1.11		A7pSr
74383341	HD 244876	DSCT	9170	1.38		A0SiSr
74721794	HD 245222	DSCT	7790	1.66		A5CrSi
74804951	HD 245423	DSCT+ACV	8260	1.41	0.667	A3Si
75242494	HD 245990	SPB	8500	1.44		A1Si
75421046	HD 246109	DSCT	8260	1.63		A2Si
75856816	HD 246685	DSCT	6270	1.59		ASiSr?
76213603	TYC 1870-1678-1	DSCT	9170	1.22		A0Sr
76294845	TYC 1866-943-1	DSCT+ACV	8500	1.42	2.841	A2SiSr
76494115	HD 81076	DSCT	7684	1.98		A2EuCr?
76532208	HD 163712	GDOR	7852	1.65		A4Sr
78182769	HD 82417	GDOR	9373	2.10		A2EuSrCr?
78562609	HD 50143	DSCT+ACV	8384	1.40	7.453	B9EuSrCr?
78784187	HD 249401	DSCT	8148	1.83		A2Si
80152411	[M67b] +25 513	DSCT	9170	1.89		B9SiSr?
81336388	TYC 1885-759-1	GDOR	9170	2.19	0.627	A0Si?
81636104	HD 252608	GDOR	9170	1.83	0.324	B9Si
84863628	HD 45541	DSCT	8516	1.40		A2/3VSi:
88091070	HD 192969	DSCT+EB	8381	1.29		A5pSi
93550171	HD 74169	ACV+GDOR	9271	1.51	4.601	kA0hA2mA7
97312819	HD 68351	SXARI+MAIA	10833	2.78	6.536	A0SiCr*
98660068	HD 3326	DSCT	7439	0.93		hA5mF0pSr
101444131	HD 47176	DSCT	7746	1.11		A6VpSr
115559920	NGC 1960 81	BCEP+SPB	16842	3.37		B9Si
116143102	HD 245725	DSCT	9170	2.34		A0Si
116247916	TYC 2408-446-1	MAIA	11300	2.15		B9SiSr
116250519	HD 245916	MAIA+SXARI	11300	2.06	1.996	B9SiCrSr
116860722	HD 246726	DSCT	7573	1.16		A5SiSr
116881415	HD 3135	DSCT	7137	1.15		F3SiCr
116995376	TYC 2413-476-1	DSCT	9069	1.62		A0Sr
118114352	HD 3772	GDOR	6789	1.06		ApSiCr:
118573876	HD 22128	DSCT	6960	1.40		A9IVpSrEuCrMn

Table A2 – continued

TIC	Name	Var Type	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
120598737	HD 213421	EA+DSCT	8716	1.80		A0Si?
122932611	HD 134185	DSCT	7400	1.72		F0Si
123231021	KIC 7582608	GDOR+ACV:+ROAP	7801	1.38	9.906	A7pEuCr
123587926	HD 50285	DSCT+ACV	9225	2.34	1.287	A0Si
127755832	HD 243356	DSCT	9170	1.45		A0Si
127846482	HD 243543	DSCT	9170	1.69		A0Sr
127956261	HD 243526	DSCT+ACV	8500	1.56		A0SiCrSr
127959761	HD 35436	DSCT	8013	1.88		A1SiSr
130587035	HD 108506	DSCT	7085	1.23		F2V+n(Cr)
133696007	HD 67165	DSCTHF+ACV	9900	1.86	0.876	A0Si
138239074	BD+41 4078	DSCT	7689	1.25		A5SiCr?
140010384	HD 72128	GDOR	9900	2.14		A0Si
143168754	HD 40765	DSCT	6767	1.50		F1SrCrEu
143842651	HD 65236	GDOR	7650	2.18		B9Si?
144276313	HD 221760	DSCTHF+ACV	8600	1.89	2.628	A0VpSrCrEu
145516106	HD 137732	ACV+DSCT	9496	2.41	3.794	B9Si
145888834	HD 76063	DSCT	9170			A0Si
145917186	HD 76141	DSCT+ACV	9450	1.89	2.538	A0Si
146373520	HD 91590	DSCT+ACV	7900	1.33	3.314	ApSi
149037452	HD 34460	GDOR	6441			F3III/IVSr
152086729	HD 224962	DSCT	6768	1.52		F0Sr
152355010	HD 156040	GDOR	7816	1.98		B9Si
152808505	HD 216641	GDOR:+ROAP	6430	0.93		FpEuCr
154714788	BD+46 3884	DSCT	7042	1.25		F0pCrEu?
155951067	HD 2202	GDOR	6827	0.62		F0p:Sr:
155966613	HD 2263	GDOR	6997	0.94		A3II/IIIp:Si:
158484992	HD 179259	DSCT	7604	1.00		A8EuCr?
158275114	ILF1 +44 20	GDOR+ROAP+2h+s	7468	1.28		A5EuCr
159647185	HD 182895	DSCT	7068	1.61		F2CrEu?
160034048	HD 118214	GDOR	9886	1.72		A1/2pSi
165011138	HD 200859	DSCT	8329	2.03		A2Si?
166351770	DM BD+35 4422	DSCT	7847	1.65		A5Si?
169971995	HD 66533	DSCT	9422	2.17		kB9hA3mA8SrCrEu
177214903	HD 53854	ACV+GDOR	7650	2.33	0.855	B9Si
177319683	HD 223660	ACV+DSCT	9000	2.16	2.821	B7IIIpSi
178108654	HD 20476	DSCTHF	9176	1.96		A5Si
178750406	HD 56206	ACV+GDOR	9900	2.02	4.906	A0Eu
180894453	BD+31 3215	GDOR	8079	1.81		ASr?
183668638	HD 71058	GDOR	7416	2.08		B9EuCrSr?
190682740	HD 76406	DSCT+ACV	8147	2.07	2.578	A0Si
191672063	HD 77809	DSCT+ACV	7925	1.60	4.749	ApSrCr:
192375956	BD+46 681	DSCT	7681	1.69		A8VSrCrEuSi
194356599	HD 653	ACV+DSCT+ROAP	10000	1.63	1.085	A0CrEu
195449631	TYC 2700-2295-1	DSCT	7116	1.95		A0Si?
196639668	HD 156808	GDOR	8324	3.95		A5EuCr
213564899	HD 338654	DSCT	7989	1.45		A0Si
215818457	HD 338735	GDOR	8593	1.21		A0Si?
231813751	HD 38471	GDOR+ACV	7650	2.08	2.429	B9Si
235568144	HD 139478	GDOR	7184	0.80		F1Sr?
235676117	HD 176281	GDOR	6850	1.16		F2pSr:
237564008	HD 50345	DSCT	8833	1.63		A0EuCr
238659021	HD 8441	DSCT	9471	2.34		kB8hA3pSrCrEu
239738736	HD 247232	DSCT	9175	1.68		A2SiCr
239758529	HD 247437	GDOR	7610	2.00		B9SiSr
239802539	2MASS J05482244+3313262	SXARI+SPB	11300	2.10	0.293	B9SiSr
239833172	HD 247794	DSCT	9170	1.69		A0Sr
245179731	HD 191836	DSCT	8010	1.76		A4/5IV/VSr
245641254	HD 16460	GDOR	6393	2.48		F1IV-VpSrEuCr:
245792896	HD 28319	DSCT+E:	8430	1.94		A9IVSr
246734602	HD 174779	GDOR	9505	2.59		ApSiCrSr
248354858	HD 7133	DSCT	7133	1.50		A3Sr
252906029	HD 50972	ACV+DSCT	9655	1.60	1.047	B9VSrCr

Table A2 – *continued*

TIC	Name	Var Type	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
257921991	HD 10783	SXARI+MAIA	10772	1.98	4.132	A2pSiSrCrFe(EuGd)
260204804	HD 131910	DSCT	6966	1.59		F4EuCr
267021905	HD 220071	DSCT+ELL	7400	1.03		A7/F0V:p:Si:Sr?
271057422	HD 75425	DSCT	8042	1.45		A0SrEuCr?
276300910	HD 134799	DSCT+ACV+ROAP	9743	1.50	7.270	A7SrCrMg
283613369	DM BD+35 4340	DSCT	7480	1.99		F0SiSr?
285856246	HD 243791	DSCT	9170	1.75		A0Sr
289228040	HD 200177	DSCT+ACV	9928	1.55	1.469	kA0hA2pCrSr
289410352	HD 74611	ACV:+GDOR	7650	2.01	7.232	B9Si
296375471	HD 131171	DSCT	7650	2.25		B9Si
298197561	HD 340577	DSCT	8461	2.22		A3SrCrEu
301946105	HD 7410	DSCT	7815	1.79		A5SrCrEu
303478699	HD 154253	DSCT+ACV	8001	1.52	3.094	A0SrCrEu
307642246	HD 72634	ACV+DSCT	9300	1.96	1.861	A0EuCrSr
307930890	HD 85672	DSCT+ROAP	7850	0.99		A3VpSr
310295579	HD 107267	DSCT	9951	2.17		B8Si
311778802	HD 39135	DSCT	8645	2.31		A0SiCrSr
311911447	TYC 2410-948-1	DSCT	10571	1.95		A0Sr?
312221714	HD 248727	DSCT	9790	1.89		A0MnSiCr
312690491	DM BD+34 1215	MAIA	11300	1.98		B9Si?
316520410	HD 21427	GDOR	9078	1.54		A3VSi:
318717035	HD 3992	DSCT	8500	1.97		A3pSi
320504339	HD 2852	DSCT	7835	1.92		A5SrEu
323432344	HD 32314	DSCT	8044	1.07		A5Si
324437240	HD 169594	DSCT+ACV	8328	1.94	1.649	ApCrSrSi
331644554	DM BD+46 3543	EA+DSCT	8450	1.17		A2Si
333808016	HD 62632	DSCT+ACV	8810	2.05	3.281	A2CrEu
341616734	HD 89069	GDOR	8941	1.65		A0SrCrEu*
342575976	HD 170005	DSCT	7785	1.59		A2pSr
343126267	BD+54 2730	DSCT	7998	1.12		F0SiSr
344177424	HD 89877	DSCT+ACV	8925	2.41	3.186	ApEuCrSr:
345426423	TYC 4004-312-1	GDOR	8217	1.46		A0Si?
348772511	HD 21190	DSCT	7028	1.62		F2IIIrEuSi:
353436357	HD 47774	DSCT+ACV	9170	2.41	2.849	A0III-IVCrEu
356088697	HD 76460	DSCT	8454	1.52		ApSrEuCr*
356439350	HD 181331	DSCT+ACV	9900	2.22	3.571	A0VpSi
361168660	HD 144059	EA+DSCT	9900	2.37		A0III:
362622494	HD 147174	DSCTHF	9900	1.72		A0SiCrSr
363387100	HD 192060	GDOR	7140	1.51		A5YSr?
363550117	HD 99458	EB+DSCT	7600	1.57		A2
364257619	HD 191426	DSCT+ACV	9900	3.55	3.184	A0Si
369711187	HD 47633	ACV+GDOR	9174	1.77	6.041	B9Si
371976932	HD 240242	DSCT	9400	1.06		A4Si
382538797	HD 145393	DSCT	7015	1.05		A9Vp:Eu:Cr:Sr:
382631655	CPD-60 922	DSCT+ACV	7295	0.91	1.446	A0Si?
385594939	[M67b]+23 477	DSCT	9400	0.84		kA2mF0SrSi
389841228	BD+38 2360	GDOR	7042	0.88		F0pSrCrEu
393799555	HD 108283	DSCT+ACV	7170	1.84	1.272	A9IVnpSr
394124612	HD 218994	DSCT+ACV+ROAP	5096	1.46	11.647	A3Sr
401529004	HD 77830	DSCT	7821	1.66		A5SrCr
408246457	HD 281886	GDOR	6547	0.64		F0pSr?
410163387	HD 76276	GDOR+ROAP	7697	1.52		A0SrCrEu
417206015	HD 205171	DSCT	9888	1.67		kA0.5mA1Vas(Si)
418241480	HD 19978	DSCT	7780	1.59		ApCrEuSr
419916333	HD 117290	DSCT	7271	1.77		A3EuCrSr
420656936	HD 4853	DSCT+ACV	8536	1.56	0.579	A3Si
426009799	HD 139855	GDOR	7609	1.53		A0Si
427377135	HD 36955	DSCTHF+ACV	8057	1.63	2.283	kA0hA2mA4CrEu
429306233	HD 97411	DSCT+ROA	10000	1.79		A0p(Si)
429501634	HD 40724	SPB	11677	2.50		B8VSiCr
429553764	HD 40696	GDOR	8187	2.12		A0Si?
429556532	TYC 1864-1509-1	GDOR	7555	1.94		A2pSr:
431029903	TYC 3982-4172-1	DSCT	7276	1.53		A3pSr
435263600	HD 218439	GDOR+ROAP	8283	1.91	3.120	A2p:Sr:Cr:Si:

Table A2 – continued

TIC	Name	Var Type	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
437231105	HD 95158	DSCT	7193	1.40		A7SrCr?
438694338	HD 117227	DSCTHF	7803	1.07		A0CrSr
445325141	HD 59660	DSCT+ACV	8251	2.30	4.283	A0EuCr?
445796153	HD 34740	ACV:+DSCTHF	7351	1.16	5.576	A0pSrSi
449026092	HD 125467	DSCT+ACV	8000	1.68	3.891	ApEuCrSr
450091404	HD 287150	DSCT	8169	1.72		A3SrCr?
452907921	HD 66853	DSCT:	7120	1.38		F2IIIpSrEuCr:
454802988	HD 133792	GDOR	9900	2.22		A0pSrCrSi
464254336	HD 90178	GDOR	9900	2.11		A0Si
470215950	HD 161704	DSCT	6408	0.57		Ap:Cr:Eu:Sr:
470680611	HD 195147	DSCT	6889	1.39		F0pSrSi

Table A3. List of new roAp and roA stars. The columns are the same as in Table A1. A colon on the variable type signifies stars with a signal-to-noise ratio $S/N < 5$.

TIC	Name	Var Type	ν (d ⁻¹)	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
4463975	TYC 5820-1216-1	ROA+ROT	174.753	7629	1.05	0.514	F0
5370150	HD 55133	ROT+ROA:	226.528	6927	0.45	3.663	F6/8(IV)
7647538	HD 27440	ROT+ROA:	248.231	6497	1.06	6.024	F5IV/V
9171107	TYC 2479-429-1	ROT+ROA	132.107	6523	0.1:	3.096	
12312526	HD 291240	ROA	66.213	8249	1.11		A2
21024812	HD 14522	ACV+ROAP	95.265	7942	1.46	13.158	A8VSrEuSi
25676603	BD+27 4042	ACV+ROAP	157.205	6568	0.86	5.495	F0SrEu
26833276	HD 10682	ACV+ROAP	136.786	6967	0.80	10.417	F0VpSr
27011098	KIC 10925227	ROT+ROA	199.341	7532	1.00	3.247	
30965889	CPD-44 3294	ROA	60.968	8773	1.18		A0
31148852	CD-46 4837	ROA	61.011	8587	1.14		A2V
33416333	HD 217249	ROA+ROT	238.461	6891	1.02	4.831	A7III
33604636	HD 42605	ACV+ROAP	108.633	8283	1.37	2.778	ApSrEuCr
36576010	HD 216018	ROAP	166.682	8400	1.24		A9VpSrCrEu
40485583	HD 227470	ROA	62.560	7501	1.20		A1IV
43135807	HD 116856	ROA	78.231	5951	0.67		G0III
48188257	KIC 11175495	EA+ROA	64.434	8554	1.36		
50656687	HD 36117	ROT+ROA:	86.170	7655	1.30	1.484	A2Va
68191357	HD 172585	ROA+ROT	63.018	8740	1.31	5.917	F
68343162	TYC 2637-1765-1	ROT+ROA	150.802	6238	0.11	5.495	
68972304	HD 231442	ROA	62.659	7059	1.66		A2
71148851	HD 233534	ROA+ROT	65.543	7762	1.17	2.967	A2
72392575	HD 225578	ACV+ROAP	135.944	7828	1.07	3.922	A5Sr?
80542072	HD 67804	ROT+ROA+FLARE	62.978	6176	1.15	1.634	A2/3IV
89757305	HD 227658	SPB+ROA	288.146	21838	3.42		B2
91224991	HD 191380	ROA+2h	100.213	6958	0.96		F8
93270207	HD 73904	ROA	79.244	9229	1.29		A2VhA0?n
96329159	HD 146313	ROT+ROA:	107.053	6575	0.92	1.420	F2V
101403577	HD 189609	ROT+ROA	64.367	5672	1.03	2.079	A1V
101624823	HD 100598	ROT+ROA	124.568	6859	1.08	4.049	F0
115642252	NGC 1960 109	BCEP+ROA	60.991	7212	2.45		B2I
120532285	HD 213258	ROA	192.349	7871	0.96		Fp
120663727	HD 49832	ROA	67.249	8754	1.24		A1V
127944540	HD 127592	ROA	217.182	6919	1.18		A8/9V GAIA
129820552	BD+36 467	ACV+ROAP	173.928	7742	0.97	6.211	ApSrEu
132923245	CD-41 3649	ROA+FLARE	78.000	8124	1.25		B9
134361875	HD 55450	ROA	72.861	8454	1.22		A0V
134860590	HD 68625	ROA+ROT	61.326	9002	1.22	3.861	A2V
143400338	BD-03 2896	ROA:	167.650	6253	0.74		F0:
146440176	HD 32488	ROA:	71.377	6660	1.03		F3/5V
148899733	HD 137015	ROA+ROT	80.805	8879	2.35	0.763	A1/2V GAIA
152896524	HD 156120	ROT+ROA+r	144.975	7906	1.22	5.587	A7/9V:
156810780	HD 51093	ROA	61.667	9097	1.25		A1V
157542967	HD 171945	ROT+ROA+r	61.051	9072	1.38	0.384	A2
159195919	HD 128360	ROA+ROT	64.081	7240	1.13	1.669	A1V
165052884	HD 51561	ROT+ROA	188.069	7711	0.84	17.857	A5
172356142	HD 46399	ROT+ROA	61.024	6047	1.04	2.004	A2V
173082020	HD 104366	ROA	67.910	8178	0.94		A3Vp
185163987	HD 72916	ROT+ROA	63.706	8731	1.17	10.989	A3V
192970685	HD 67871	ROT+ROA	61.222	7868	1.34	0.731	A2V
193808452	BD+42 3743	ROA:	224.721	7227	3.39		A2II
194356599	HD 653	ACV+DSCT+ROAP	61.102	10000	1.63	1.085	A0CrEu
198107724	HD 121825	ROA:	183.429	5796	0.17		F9V
206481548	HD 209719	ROT+ROA	62.860	8007	1.13	1.125	A1IV/V
231277305	HD 17703	ROA:	124.867	6298	0.63		F6V
231953659	TYC 8106-673-1	ROA	81.132	6080	0.49		
233200244	HD 161846	ROT+ROA+r	124.471	8930	1.38	7.299	A3
233398254	HD 191490	ROT+ROA	83.931	8734	1.27	3.049	A2
242198772	HD 294848	ROT+ROA+r	202.346	8544	1.16	1.616	A7
244991415	HD 339572	ROA+ROT	206.463	7906	1.25	8.065	A7
246937824	HD 14126	ROA	173.131	7461	0.98		A2

Table A3 – continued

TIC	Name	Var Type	ν (d ⁻¹)	T_{eff} (K)	$\log \frac{L}{L_{\odot}}$ (dex)	P_{rot} (d)	Sp Type
249648704	HD 215449	ROT+ROA:	103.634	8223	1.04	4.405	A7III
255988376	HD 158952	ROT+ROA	73.386	9180	1.23	12.500	A0V
257168451	BD+00 2086	ROA	63.038	8501	1.12		A2
258626846	TYC 4451-487-1	ROT+ROA	61.364	7522	0.96	3.584	
259017938	HD 210684	ROT+ROA+r	116.825	7770	1.31	5.102	F0
259019958	HD 130232	ROA	80.703	8210	1.14		A0V
261191518	HD 155945	ROT+ROA	144.732	6774	1.11	0.777	F0V
265886274	HD 347793	ROA	71.767	8214	1.26		A0
266806814	HD 62526	ROT+ROA	190.441	8681	1.19	12.821	A0
274644686	HD 227534	BCEP+ROA	67.054	18950	1.85		B5:V:
276300910	HD 134799	DSCT+ACV+ROAP	65.304	9743	1.50	7.270	F0IIISrCrMg
282086296	HD 311505	ROT+ROA:	277.490	6662	0.35	4.082	G0
287636619	TYC 9201-1206-1	ROA:	243.548	6472	0.57		
288242217	HD 158012	ROT+ROA	69.212	7480	1.53	5.051	F0
293290586	HD 129842	ROT+ROA	156.888	13520	2.83	0.672	B8/9IV/V
295254609	HD 163362	ROT+ROA	74.176	8548	1.24	166.667	A2V
298052991	BD+78 451	ROT+ROA	197.951	7680	0.92	10.638	A2
299467756	HD 294788	ROT+ROA	81.352	8758	1.74	1.733	A0V
304425262	HD 103079	SPB+BCEP+ROA	61.337	20560	3.02		B4IV
306090385	HD 344856	ROT+ROA	63.180	8909	1.24	4.926	A0
306250556	HD 301370	ROT+ROA	204.338	7494	1.17	4.651	A3
307606851	HD 135344	ROA	79.938	9055	1.20		A0V
307930890	HD 85672	DSCT+ROAP	65.363	7850	0.99		A3VpSr
308085294	HD 74388	ACV+ROAP:	179.185	7654	2.39	4.323	B8Si
308752235	TYC 8932-623-1	ROT+ROA:	78.805	6109	-0.01	8.000	
313261813	HD 119476	GDOR+ROT+ROA	79.115	9058	1.32	0.442	A1.5V
319740524	HD 182396	ROT+ROA	70.022	8673	1.2:	2.890	A2V
335457083	HD 48409	ROT+ROA+r	180.075	8510	1.10	2.907	A3
349071261	HD 284113	EP+ROA	101.213	6381	0.54		F8
352787151	BD+35 5094	ROAP	60.138	7034	1.55		F0SrEu
355281777	HD 56663	ROT+ROA	68.121	8887	1.22	4.149	A1/2V
358289524	HD 26564	ROA	63.282	8690	1.31		A1V
358464975	CPD-60 933	ROA+GDOR	66.671	8675	1.22		A2
359030908	HD 104956	ROA	206.915	6125	0.34		F8
360020620	HD 190833	GDOR+ROT+FLARE+ROA	64.928	7406	1.26	0.568	A0V
362351038	HD 140498	ROA	70.091	8266	1.19		A0V
366554105	HD 210695	ROT+ROA:	97.151	6972	1.05	0.806	F5
376942777	HD 274350	ROA	81.453	6733	1.01		F2
380584567	BD+12 2366	ROA:	115.405	6243	0.78		F8
383657251	HD 77422	ROA+ROT	62.325	8760	1.14	1.603	A3V
383704522	HD 129912	ROA:	203.033	6659	0.68		F3V
385939181	HD 302131	ROT+ROA	60.737	9317	1.22	4.785	A2
389879483	HD 100474	ROA:	82.936	6420	1.03		F5V
392924760	HD 120200	GDOR+ROA:	198.147	7211	0.90		A5
394860395	BD+35 3616	ACV+ROAP	101.949	11007	1.36	6.667	F0SrEu
398476730	HD 104125	ROT+ROA	69.088	8656	1.35	1.280	A2V
405892692	BD+49 3179	ROT+ROA	101.159	7527	0.85	0.383	F0
411923607	CD-63 1324	ROA	101.793	6232	0.21		
423315454	2MASS J23293590+1022092	ROA+ROT	63.379	8086	1.46	1.387	A1
427398460	HD 294239	ROA	83.515	8772	1.22		B5
427400331	HD 290662	ACV+ROAP	75.050	7418	0.70	0.943	A0Vp
435263600	HD 218439	GDOR+ACV+ROAP	94.796	8283	1.91	3.106	A2p:Sr:Cr:Si:
442896389	HD 34995	ROT+ROA	174.274	6717	0.61	3.759	F2V
444006544	HD 74911	GDOR+ROA	63.549	7950	1.50		A2IV
445493624	HD 11948	ACV+ROAP:	105.857	8344	1.41	7.333	A5SrEu
450851808	HD 98435	ROT+ROA	63.945	7394	1.31	2.976	A1/2V
453826702	HD 22032	ACV+ROAP+r	139.102	7601	1.21	4.854	A3SrEuCr
456673854	HD 59702	ACV+ROAP+r	273.822	8100	1.04	5.435	A7pSrEu
464740586	HD 302881	ROA	67.454	8511	1.12		A2
464807201	HD 29839	ROA+ROT	78.447	7956	1.65	5.682	A1V
630844439	HD 10581	GDOR+ACV+ROAP	289.721	7018	1.14	1.664	A8m