NEW PHOTOMETRICALLY VARIABLE MAGNETIC CHEMICALLY PECULIAR STARS IN THE ASAS-3 ARCHIVE

STEFFAN HÜMMERICH1,2, ERNST PAUZEN3, AND KLAUS BERNHARD1,2

1 American Association of Variable Star Observers (AAVSO), Cambridge, MA, USA; enhan@rz-online.de
2 Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne e.V. (BAV), Berlin, Germany
3 Department of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

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ABSTRACT

The magnetic Ap or CP2 stars are natural atomic and magnetic laboratories. Strictly periodic changes are observed in the spectra and brightness of these stars, which allow the derivation of rotational periods. Related to this group of objects are the He-weak (CP4) and He-rich stars, some of which also undergo brightness changes due to rotational modulation. Increasing the sample size of known rotational periods among CP2/4 stars is important and will contribute to our understanding of these objects and their evolution in time. We have compiled an extensive target list of CP2/4 stars from the General Catalog of Ap, HgMn, and Am stars, including several early-type (spectral types B/A) variables of undetermined type from the International Variable Star Index. We investigated our sample stars using publicly available observations from the ASAS-3 archive. Our previous efforts in this respect led to the discovery of 323 variable stars. Using a refined analysis approach, we were able to identify another 360 stars exhibiting photometric variability in ASAS-3 data. Summery data, folded light curves and, if available, information from the literature are presented for our final sample, which is composed of 334 bona-fide $\alpha^2$ Canum Venaticorum (ACV) variables, 23 ACV candidates, and 3 eclipsing binary systems. Interesting and unusual objects are discussed in detail. In particular, we call attention to HD 66051 (V414 Pup), which is an eclipsing binary system showing obvious rotational modulation of the light curve due to the presence of an ACV variable in the system.

Key words: stars: chemically peculiar – stars: individual (V414 Pup) – stars: rotation – stars: variables: general

Supporting material: figure set, machine-readable table

1. INTRODUCTION

Chemically peculiar (CP) stars, which comprise about 15% of the upper main-sequence stars between spectral types early B to early F, are characterized by abnormal line strengths of one or several elements. This peculiar abundance pattern is thought to be produced by selective processes (radiative levitation, gravitational settling) operating in calm radiative atmospheres (Richer et al. 2000). Evidence has accumulated that there is no clear boundary between normal and CP stars but rather a smooth transition in regard to peculiarity (Lodén & Sundman 1987). Furthermore, the CP phenomenon is not restricted to a particular evolutionary stage (Kochukhov & Bagnulo 2006). Preston (1974) divided the CP stars into the following four subgroups: CP1 stars (the metallic line or Am/Fm stars), CP2 stars (the magnetic Bp/Ap stars), CP3 stars (the HgMn stars), and CP4 stars (the He-weak stars). Further groups of CP stars were subsequently defined, such as, e.g., the He-strong stars (Berger 1956; MacConnell et al. 1970) or the $\lambda$ Bootis stars (Parenago 1958; Pauzzen 2004).

The CP2 stars differ from the CP1 and CP3 objects in that they possess globally organized magnetic fields from about 300 G to several tens of kiloGauss (Aurière et al. 2007; Kochukhov 2011), which also holds true for the CP4 objects. CP2 stars show a nonuniform distribution of chemical elements, which manifests itself in the formation of spots and patches of enhanced element abundance (Michaud et al. 1981), in which flux is redistributed through bound–free and bound–bound transitions (e.g., Krtička et al. 2013). Therefore, as the star rotates, strictly periodic changes are observed in the spectra and brightness of many CP2 stars, which are satisfactorily explained by the oblique rotator model (Stibbs 1950). CP2 stars exhibiting photometric variability are traditionally referred to as $\alpha^2$ Canum Venaticorum (ACV) variables (Samus et al. 2007–2016).

CP3 stars do not show strong large-scale organized magnetic fields, and the discussion about the presence of tangled magnetic fields is ongoing (e.g., Kochukhov et al. 2013b). However, the line-profile variations detected in the spectra of these stars have also been interpreted in terms of abundance inhomogeneities (Adelman et al. 2002; Hubrig et al. 2006). Therefore, rotationally induced photometric variability at some level would be expected. While photometric variations in CP3 stars have been established beyond doubt, the underlying mechanism is still a matter of debate (e.g., Morel et al. 2014). However, rotational modulation due to surface spots in CP3 stars is believed to produce only marginal photometric amplitudes (Pauzzen et al. 2013), which can likely be studied with high-precision (space) photometry only. In the preparatory stage of our investigation, some CP3 stars were checked for light variability in ASAS-3 data, albeit with null results, which substantiates this assumption. However, this question is beyond the scope of the present investigation, which concentrates on the classical magnetic CP2/4 stars.

CP2 stars are natural atomic and magnetic laboratories and, because of their unusual abundance patterns, ideal testing grounds for the evaluation of model atmospheres (Krtička et al. 2009). Increasing the sample of known CP2 stars is therefore an important task, and considerable effort has been devoted to...
it in the past (Manfroid & Mathys 1986; Paunzen & Maitzen 1998; Paunzen et al. 2011; Wraith et al. 2012).

Our own efforts in this respect (Bernhard et al. 2015a, 2015b) have produced extensive lists of new ACV variables and candidates that have been found by an investigation of publicly available sky survey data. Bernhard et al. (2015a, Paper 1 hereafter) investigated the photometric variability of Ap stars using observations from the third phase of the All Sky Automated Survey (ASAS-3, Pojmanski 2002) and identified 323 variable stars (mostly ACV variables), 246 of which were reported as variable objects for the first time. As an extension of this work, we here report on the discovery of an additional 360 variable stars in ASAS-3 data, which have been found by a refined analysis approach. In agreement with our expectations, the new sample is also composed mostly of bona-fide ACV variables.

Observations and target selection are described in Section 2, and data analysis and classification are presented in Section 3. Results are presented and discussed in Section 4, and we conclude in Section 5.

2. OBSERVATIONS AND TARGET STARS

2.1. Characteristics of ASAS-3 Data

The aim of the All Sky Automated Survey (ASAS) is the detection and investigation of any kind of photometric variability. To this end, ASAS constantly monitored the entire southern sky and part of the northern sky to about $\delta < +28^\circ$. The third phase of the project, ASAS-3, lasted from 2000 until 2009 (Pojmanski 2002). The employed instrumentation, which was situated at the 10 inch astrophot dome of the Las Campanas Observatory in Chile, consisted of two wide-field telescopes equipped with $f/2.8$ 200 mm Minolta lenses and 2048 $\times$ 2048 AP 10 Apogee detectors that covered a field of sky of $8.8^\circ \times 8.8^\circ$. About 10$^7$ sources brighter than $V \approx 14$ mag were monitored in Johnson V. The achieved CCD resolution was about 14 arcsec$^{-1}$, which led to an astrometric accuracy of around 3″–5″ for bright stars and up to 15″ for fainter stars. As a result, photometry in crowded fields, as in star clusters, is rather uncertain. A field was typically observed every one, two, or three days (Pigulski 2014). This observing cadence results in strong daily aliasing and renders the interpretation of the resulting Fourier amplitude spectra ambiguous.

The ASAS-3 archive contains reasonable photometry for stars in the magnitude range of $7 \lesssim V \lesssim 14$. However, the most accurate data were obtained for targets in the magnitude range of $8 \lesssim V \lesssim 10$. Here, the typical scatter is about 0.01 mag (e.g., Pigulski 2014). However, because of the long time base of almost 10 years, ASAS-3 data allow for the detection of periodic signals with very small amplitudes. For instance, David et al. (2014) identified periodic variables with a range of variability of 0.01–0.02 mag in the magnitude range of $7 \lesssim V \lesssim 10$. Pigulski (2014) estimated that periodic signals with amplitudes as low as about 5 millimag (mmag) can be detected.

Pojmanski (2002) has shown that the zero-points of the ASAS-3 and Hipparcos photometry agree to within about $\pm 0.015$ mag for stars lying close to the frame center. However, flat-fielding issues, missing color information, and blending may result in much larger differences. We have investigated the agreement between mean ASAS-3 V magnitudes and V magnitudes given by Kharchenko (2001) for the stars of our final sample. The results are shown in Figure 1 and indicate very good general agreement between both sources. In most cases, unresolved close companions are responsible for the observed discrepancies.

2.2. Target Stars

An initial list of target stars was created by selecting CP2 stars or CP2 star candidates and He-weak (CP4)/He-strong objects from the most recent version of the Catalog of Ap, HgMn, and Am stars (Renson & Manfroid 2009, RM09 hereafter). Objects in the RM09 catalog are not explicitly subdivided according to the classification established by Preston (1974). We therefore resorted to the listed spectral types to distinguish between the different groups of CP stars (mainly denoted as Si, Sr, Sr Eu Si, He weak, HgMn, and so on). The resulting list of stars was cross-matched with the Tycho-2 catalog (Høg et al. 2000); unlike our initial approach, where we defined a cut-off at $V_T < 11$ mag (see Paper 1, Section 2), no brightness limit was imposed.

In addition to this, a systematic investigation of early-type (spectral types B/A) variable stars of undetermined type in the AAVSO International Variable Star Index (VSX; Watson 2006) yielded additional ACV candidates, which were added to our target list.

We consulted the GCVS (Samus et al. 2007–2016), VSX, SIMBAD (Wenger et al. 2000), and VizieR (Ochsenbein et al. 2000) databases in order to check for an entry in variability catalogs and to collect literature information on our target stars. Known ACV variables with well-determined parameters were dropped from our sample; suspected or misclassified variables and variables of undetermined type were kept.
3. DATA ANALYSIS AND CLASSIFICATION

3.1. Data Processing and Period Analysis

The light curves of our sample stars were downloaded from the ASAS-3 website. For the present investigation, a refined analysis approach was developed with the intention of discovering variable objects that might have been missed by the imposed criteria in our previous work (Paper 1). In order to retain as many objects as possible, no lower limit was imposed on the number of observations in the ASAS-3 archive. In Paper 1, we restricted our analysis to promising candidates in order to keep our sample down to a manageable size. As promising candidates, we defined stars showing a larger scatter than usually observed for apparently constant stars in the corresponding magnitude range with comparable instruments (Hartman et al. 2004). No such criteria were imposed in the present investigation; instead, every individual ASAS data set was roughly cleaned of outliers and searched for periodic signals in the frequency domain of $0 < f < f_r(d/c) < 0.20$ using PERIOD04 (Lenz & Breger 2005).

Furthermore, the periodicity detection threshold was lowered significantly. Only objects with semi-amplitudes of $\geq 0.007$ mag (as derived with PERIOD04) were considered in Paper 1. In the present investigation, all objects exhibiting variability with a semi-amplitude of at least 0.004 mag were subjected to a more detailed analysis. This limit is an experiential value based on our own extensive experience in dealing with the ASAS-3 data and the results of David et al. (2014) and Pigulski (2014). It was chosen as a compromise between retaining variables with small amplitudes and eliminating spurious detections.

In the next step of the analysis, left-over data points with a quality flag of “D” (=“worst data, probably useless”) were rejected and remaining outliers were carefully removed by visual inspection. Furthermore, the data were checked for the presence of systematic trends. These were mostly due to strong blending effects, which might result in significant additional scatter due to the inclusion of part of a neighboring star’s flux (Sitek & Pojmanski 2014) or instrumental long-term trends that could introduce spurious signals into the data. Depending on the severity of artifacts, the affected data sets were either rejected or the trends were removed.

To refine the initial frequency analysis, the pretreated data sets were again searched for periodic signals in the frequency domain of $0 < f < f_r(d/c) < 0.10$ with PERIOD04. The data were folded on the resulting best fitting frequency and visually inspected. Objects exhibiting convincing phase plots were kept.

The light curves of CP2 stars can be well described by a sine wave and its first harmonic (North 1984; Mathys & Manfroid 1985; Heck et al. 1987; Bernhard et al. 2015b). We performed a least-squares fit to the data using PERIOD04. Each light curve was fitted using a Fourier series consisting of the fundamental sine wave and its first harmonic, from which the light-curve parameters (semi-amplitudes $A_1$, $A_2$, and the corresponding phases $\phi_1$, $\phi_2$) were derived.

As pointed out, the light curves of most ACV variables are sinusoidal. In orientations where two photometric spots of overabundant optically active elements come into view during a single rotation cycle, the light curve becomes a double wave (Maizena 1980). If the two spots are of similar extent and photometric properties, the resulting “maxima” will be of approximately the same height. Therefore, a twice longer (or shorter) rotation period cannot be excluded. This holds especially true for objects with very small amplitudes and/or significant scatter in their light curves.

In addition to that, alias periods cannot be totally excluded because of the strong daily aliasing inherent to ASAS-3 data (see Section 2.1). However, we have checked the period solution of all doubtful cases and are confident that we have come up with the period that fits ASAS-3 data best. This assumption is further corroborated by the generally very good agreement of our period solutions to those from the literature (see also Paper 1).

3.2. Classification

For the final classification, all available information (spectral type, color indices, period, shape of the light curve, and Fourier amplitude spectrum) was taken into account. Except for the eclipsing binary systems (see below), all stars in our final sample exhibit a variability pattern that is generally in accordance with rotational modulation caused by spots. HD 66051 (V414 Pup) is a special case in that it clearly shows both orbital (eclipses) and rotational modulation.

However, caution has to be taken because it is not straightforward to distinguish between variability induced by rotation and other sources such as, e.g., pulsation or orbital motion. This holds especially true when analyzing variable stars whose photometric amplitudes are near the detection limit of the employed data, as is the case for many of our targets.

Pulsation as the underlying mechanism of the observed variability can be ruled out for most objects of our sample on the following grounds. The vast majority of our sample stars is found between spectral types B7 to A5 (see Figure 2). Therefore, pulsators that are exclusively found among earlier spectral types, such as, e.g., $\beta$ Cephei variables (GCVS-type Bcep, spectral types $\sim$O8–B6), or primarily among later spectral types, such as, e.g., the $\gamma$ Doradus stars (GCVS-type GDOR, spectral types $\sim$A7–F7), are not expected to contribute much to our sample. Of course, inaccuracies/difficulties in spectral classification have to be considered, and the spectral
types shown in Figure 2 might be uncertain by several subclasses.

Furthermore, our target stars exhibit photometric periods longer than $P > 0.5$ days. We can thus exclude the presence of δ Scuti variables (GCVS-type DSCT) or other short period pulsators.

On the other hand, some types of pulsating variables partly overlap with ACV stars in respect to spectral type and period. The so-called slowly pulsating B (GCVS-type SPB) stars, for instance, are encountered down to spectral type B9 (Figure 2) and exhibit periods between about 0.4 and 5 days. The γ Doradus stars are found between spectral types A7 to F7; observed periods usually range from 0.3 to 3 days.

One way of distinguishing these types of variable stars is an investigation of their Fourier amplitude spectra. Many kinds of pulsators, such as, e.g., SPB and γ Doradus stars, show multiple periods and quite different frequency spectra from rotating variables. For instance, harmonics of pulsation modes are only expected to be present in frequency spectra when the amplitude is large. On the other hand, harmonics are a consequence of localized spots and a characteristic of the frequency spectra of rotating variables (Balona et al. 2015).

Spots form and decay in late-type, active stars, and differential rotation might lead to the presence of multiple, closely spaced periods in these objects (Reinhold & Gizon 2015). However, the presence of starspots in stars with radiative envelopes, like B/A stars, is still a matter of some controversy. Recently, Balona and coworkers have collected evidence that A-type stars are active and show starspots in the same way as their cooler counterparts (e.g., Balona 2013). Nevertheless, the spots on CP2 stars are of a different nature (abundance patches) and constitute durable configurations that remain stable for decades, probably as a consequence of strong magnetic fields.

Differential rotation, however, plays an important role in A-type stars (Amler-von Eiff & Reiners 2012; Szklarski & Arlt 2013; Balona & Abedigamba 2016). However, to our knowledge, no study of the possible effects of differential rotation on CP2 star light curves exists. Judging from the stability of the periods and light curves among ACV variables, we assume that these effects, if present, are generally small. However, it must not be dismissed that the presence of multiple, closely spaced frequencies in the Fourier amplitude spectra of early-type stars might be due to differential rotation and need not automatically imply pulsation. Apart from this special scenario, however, the presence of multiple periods is not to be expected in CP2 stars and interpreted by us as an indication of pulsation in a non-CP2 star as the underlying mechanism of the observed photometric variability.

Figure 3 shows the Fourier amplitude spectra of two B-type stars and illustrates the described differences in the frequency spectra between a multi-periodic, pulsating variable (NSV 24561, spectral type B3, likely an SPB star; left panels) and a rotating variable (HD 63204, spectral type B9ps, a confirmed ACV variable, see Bernhard et al. 2015a). No harmonics are seen in the spectrum of NSV 24561, which exhibits two significant low frequencies. In contrast, only one frequency and its first harmonic are present in the frequency spectrum of HD 63204.

It has to be kept in mind, though, that these assumptions are simplifications that do not represent nature with all its intricacies. For instance, recent evidence from Kepler data indicates that rotational frequencies might possibly be present in SPB variables and result in the presence of harmonics in the corresponding Fourier amplitude spectra (Balona et al. 2015).

Finally, and most importantly, the spectra of all these kinds of pulsating variables are not characterized by the abnormal abundance patterns of the CP2/4 stars, which are a confirmed characteristic of most of our target stars and are expected for the CP2 star candidates in our sample. Generally, pulsation is not to be expected in CP2 stars. The only proven form of pulsational variability among this type of CP stars is observed in the so-called rapidly oscillating Ap (roAp) stars (Kurtz 1982), which exhibit photometric variability in the period range of 5–20 minutes (high-overtone, low-degree, and non-radial pulsation modes). This is very different from what has been observed for our sample stars. We therefore feel confident in ruling out pulsation as the underlying cause of the observed photometric variability in most of our sample stars.

The discrimination between rotational modulation and variability induced by orbital motion (as observed in ellipsoidal variables, GCVS-type ELL, and eclipsing binaries) is more difficult, though. Generally, it is not possible to distinguish between both types of variations without additional spectroscopic information (Paper 1; Balona et al. 2015). For some CP stars, for instance, a double-wave structure of the photometric light curve has been observed (Maitzen 1980). The light curves of these “double-humped” ACVs are not to be distinguished from the light curves of ellipsoidal variables on grounds of single-passband photometric data alone. However, it has been shown that the incidence of ellipsoidal or eclipsing variables among CP2 stars is very low (Gerbaldi et al. 1985; North & Debernard 2004; Hubrig et al. 2014) and even in a sample of some hundred stars, only very few ellipsoidal or eclipsing variable star candidates are to be expected (see Paper 1).

We have identified three eclipsing binary stars among our targets (CPD-20 1640, HD 66051, and HD 149334, see Section 4). While the system of HD 66051 (V414 Pup) definitely hosts...
a CP2 star, the CP classification of the other two objects is doubtful; thus, spectroscopic investigations are needed to confirm or reject the assumed presence of a CP2 star in these systems. Furthermore, with the available data, we are not able to distinguish between rotational and orbital modulation as the underlying cause of the photometric variability of the CP4 star HD 161733A. Section 4.2 provides a detailed discussion of these objects.

Before the background of the characteristic light variations and Fourier amplitude spectra, the confirmed CP2/4 nature of our targets, and the available spectral classifications, which go along well with the observed color indices, the most likely explanation of the observed light variations in the majority of our sample stars is the redistribution of flux in spots of overabundant optically active chemical elements. We are therefore confident that most of the confirmed CP2/4 stars in our sample are bona-fide ACV variables \((N = 334)\). The few exceptions or special cases are commented on in Section 4.2.

This assumption is further corroborated by the fact that (with the exception of the eclipsing binaries) all light curves of our sample stars can be well represented by a sine wave and its first harmonic—a procedure which has been shown to adequately describe the light curves of ACV variables (see Section 3.1). The photometrically variable CP2 star candidates in our sample are here proposed as ACV variable candidates (type ACV; in Table 2; \(N = 23\)) on grounds of their periods and typical photometric variability but need spectroscopic confirmation of their CP status. The two CP4 objects and the He-strong star are also designated as ACV candidates, as other mechanisms beside rotational modulation might be at work in these objects (Section 4.2).

### 4. RESULTS

#### 4.1. Presentation of Results

Employing the methodology outlined above (Sections 2 and 3), 360 stars exhibiting photometric variability in the accuracy limit of the ASAS-3 data were identified among the stars of our target list. We have ruled out pulsation as the underlying mechanism of the observed variability in most of our targets and are confident of the applicability of our classifications. Table 1 gives statistical information on the composition of the final sample.

| Type                        | Number of Objects |
|-----------------------------|-------------------|
| ACV variables               | 334               |
| ACV variable candidates     | 23                |
| Eclipsing binary systems    | 3                 |
| Total of variable stars     | 360               |

We have searched the SIMBAD, VizieR, and VSX databases for previously published information on our targets. According to these sources, most of the investigated CP stars have never been the subject of a light variability analysis before and are presented here as variable stars for the first time. Some of our target stars have been previously investigated and found constant or probably constant; other objects have been identified as variable stars with or without a given period in the literature, but their variability types have not been determined or they have been misclassified. Table 2 presents essential data and light-curve fit parameters for our sample stars and is organized as follows.

1. Column 1: star name, HD number, or other conventional identification.
2. Column 2: identification number from RM09.
3. Column 3: R.A. \((\text{J2000}; \text{Tycho-2})\).
4. Column 4: decl. \((\text{J2000}; \text{Tycho-2})\).
5. Column 5: variability type, according to GCVS convention \((\text{ACV}/\text{ACV}/\text{EA})\).
6. Column 6: \(V\) magnitude range, as derived from the Fourier fit to the ASAS-3 data.
7. Column 7: period \((\text{day})\).
8. Column 8: epoch \((\text{HJD}-2450000)\); time of maximum is indicated for ACV variables or candidates, time of minimum for the eclipsing binary systems.
9. Column 9: semi-amplitude of the fundamental variation \((A_1)\).
10. Column 10: semi-amplitude of the first harmonic variation \((A_2)\).
11. Column 11: phase of the fundamental variation \((\phi_1)\).
12. Column 12: phase of the first harmonic variation \((\phi_2)\).
13. Column 13: Spectral classification, as listed in RM09; it is noteworthy that, as in the original catalog, the “p” denoting peculiarity has been omitted from the spectral classifications taken from RM09. For the five stars not included in this catalog, the spectral types have been gleaned from the VSX and verified using the VizieR and SIMBAD catalog services.
14. Column 14: \((B - V)\) index, taken from Kharchenko \((2001)\).
15. Column 15: \((J - K_s)\) index, as derived from the 2MASS catalog \((\text{Skrutskie et al. 2006})\).

The light curves of all objects, folded with the periods listed in Table 2, are presented in the Appendix (see Figure 8). Information from the literature and miscellaneous remarks on individual objects are listed in Table 3, which is organized as follows.

1. Column 1: star name, HD number, or other conventional identification.
2. Column 2: variable star designation from the literature.
3. Column 3: variable star type from the literature.
4. Column 4: period \((\text{day})\) from the literature.
5. Column 5: period \((\text{day})\) from this work.
6. Column 6: reference in which, to the best of our knowledge, the object has been announced as a variable star for the first time.
7. Column 7: remarks/comments of a miscellaneous nature; an asterisk denotes stars whose status as CP objects is doubtful according to RM09.

Table 2 is available in its entirety in machine-readable form. We are currently working on a statistical paper on the

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\(^5\) Columns 8–11 have only been calculated for ACV variables or candidates. In the case of HD 66051 \((\text{V414 Pup})\), the corresponding values have been calculated from a fit to the out-of-eclipse, rotationally induced variability (see Section 4.2.2).

\(^6\) The calculation of the phase values has been based on the times of observations as provided by the ASAS-3 database, i.e., HJD-2450000.
| Star ID | Type | Range (V) (mag) | Period (day) | Epoch (HJD) (day) | *A* (mag) | *A* (mag) | *P* (rad) | *P* (rad) | Spectral Type | (B − V) (mag) | (J − Ks) (mag) |
|--------|------|----------------|-------------|------------------|------------|------------|----------|----------|---------------|---------------|---------------|
| HD 2957 | ACV | 8.48–8.51 | 6.6327(3) | 4627.91(9) | 0.011 | 0.002 | 0.846 | 0.750 | B9 Cr Eu | +0.052 | −0.017 |
| HD 3885 | ACV | 9.79–9.81 | 1.81508(4) | 2910.72(4) | 0.007 | 0.009 | 0.348 | 0.449 | B9 Si | −0.090 | −0.079 |
| HD 5823 | ACV | 9.95–9.97 | 1.24520(2) | 3765.53(2) | 0.007 | 0.004 | 0.723 | 0.646 | F2 Sr Eu Cr | +0.304 | +0.176 |
| HD 8783 | ACV | 7.80–7.82 | 19.396(5) | 3794.5(4) | 0.009 | 0.001 | 0.102 | 0.715 | A2 Sr Eu Cr | +0.150 | +0.039 |
| HD 12559 | ACV | 8.81–8.84 | 4.0358(3) | 3338.62(8) | 0.010 | 0.012 | 0.479 | 0.293 | A2 | +0.092 | −0.034 |
| HD 16145 | ACV | 7.64–7.67 | 2.23766(7) | 4525.52(4) | 0.011 | 0.002 | 0.342 | 0.873 | A0 Cr Sr Eu | +0.117 | −0.023 |
| HD 20505 | ACV | 9.88–9.90 | 2.04401(5) | 2666.49(4) | 0.009 | 0.002 | 0.222 | 0.726 | A2 Cr Sr | +0.120 | +0.001 |
| HD 22032 | ACV | 9.05–9.07 | 4.8589(3) | 3031.57(9) | 0.010 | 0.001 | 0.839 | 0.523 | A3 Sr Eu Cr | +0.455 | +0.056 |
| HD 23509 | ACV | 7.75–7.78 | 1.48786(3) | 3010.64(3) | 0.012 | 0.002 | 0.302 | 0.426 | A3 | +0.309 | +0.167 |
| HD 27210 | ACV | 10.09–10.12 | 1.01438(1) | 3447.55(2) | 0.015 | 0.000 | 0.120 | ... | A0 | +0.064 | −0.046 |
| HD 28238 | ACV | 9.11–9.12 | 24.743(7) | 2676.5(5) | 0.007 | 0.001 | 0.615 | 0.177 | A0 Sr Cr Eu | +0.241 | +0.053 |
| HD 30374 | ACV | 10.02–10.04 | 1.55631(3) | 3018.65(3) | 0.008 | 0.003 | 0.097 | 0.580 | A0 Sr Eu Cr | +0.105 | +0.081 |
| HD 240563 | ACV | 10.09–10.12 | 2.9447(1) | 4399.78(6) | 0.015 | 0.003 | 0.646 | 0.601 | A3 Sr | +0.216 | +0.078 |
| HD 245155 | ACV | 9.67–9.69 | 0.70570(7) | 3730.62(1) | 0.009 | 0.001 | 0.809 | 0.251 | B9 Si Sr | +0.080 | +0.109 |
| HD 38417 | ACV | 9.61–9.63 | 2.16619(6) | 3086.56(4) | 0.002 | 0.008 | 0.096 | 0.011 | A0 Sr | +0.121 | +0.044 |
| HD 38912 | ACV | 9.46–9.49 | 1.46279(2) | 2539.74(3) | 0.013 | 0.003 | 0.608 | 0.148 | B8 Si | +0.266 | +0.106 |
| HD 39082 | ACV | 9.41–9.43 | 0.76477(6) | 4877.58(2) | 0.007 | 0.001 | 0.045 | 0.341 | B9 Sr Cr Eu | +0.039 | −0.041 |
| HD 40071 | ACV | 8.06–8.08 | 1.98735(5) | 4477.82(4) | 0.005 | 0.005 | 0.744 | 0.369 | B9 Si | −0.042 | −0.062 |
| HD 40383 | ACV | 8.98–9.00 | 4.0364(3) | 3644.86(8) | 0.009 | 0.007 | 0.739 | 0.771 | B9 Si | +0.215 | +0.059 |
| HD 40678 | ACV | 7.37–7.39 | 22.029(6) | 2678.2(4) | 0.012 | 0.001 | 0.238 | 0.541 | A0 Sr Si | +0.158 | −0.085 |

(This table is available in its entirety in machine-readable form.)
| Star            | Var. Desig. Literature | Var. Type Literature | Period (day) Literature | Period (day) This work | Reference | Remarks/Comments                                                                 |
|-----------------|------------------------|----------------------|-------------------------|------------------------|-----------------|----------------------------------------------------------------------------------|
| HD 2957         |                        |                      |                         |                        |                 | Null result for roAp pulsations (Martinez & Kurtz 1994).                         |
| HD 3885         | NSV 15149              | VAR                  |                         | 1.81508(4)             | Wesselius et al. (1982) | Null result for roAp pulsations (Kochukhov et al. 2013a).                        |
| HD 5823         |                        |                      |                         | 1.24520(2)             |                 |                                                                                  |
| HD 8783         | SMC V2339              | VAR: 21(or 1.05)? (GCVS) |                         | 19.396(5)              | GCVS            | Non-member of the SMC according to the GCVS. The given period values are derived from variations of the peculiarity index $\Delta a$. |
| HD 12559        | HIP 9602               | VAR                  | 2.01833 (VSX); 2.01837 (R12) | 4.0358(3)              | Koen & Eyer (2002) | R12: SPB/ACV (prob: 0.24/0.51)                                                   |
| HD 16145        |                        |                      | 2.24(or 4.47)? (RM09)   | 2.23766(7)             |                 |                                                                                  |
| HD 23509        | HIP 17239              | VAR                  | 1.48779 (VSX); 1.48765 (R12) | 1.48786(3)             | Koen & Eyer (2002) | R12: SPB/DSCTC (prob: 0.23/0.33)                                                |
| HD 27210        |                        |                      |                          |                        |                 |                                                                                  |
| HD 240563       |                        |                      |                          |                        |                 | Constant or quality of data prevented detection (W12).                            |
| HD 245155       |                        |                      |                          |                        |                 |                                                                                  |
| HD 38417        |                        |                      |                          |                        |                 |                                                                                  |
| HD 39092        | NSV 16689              | VAR                  | 0.76484 (VSX)           | 2.66482(9)             | Vogt & Faundez (1979) | Constant or quality of data prevented detection (W12).                            |
| HD 40678        |                        |                      |                          |                        |                 |                                                                                  |
| BD-06 1402      | HIP 28864              | VAR DCEP-FU/MISC     | 1.13065 (VSX)           | 1.13063(2)             | Koen & Eyer (2002) | R12: EB/SPB (prob: 0.15/0.57)                                                   |
| HD 41869        |                        |                      |                          | 5.2350(4)              | Rufener & Bartholdi (1982) | Constant or probably constant, blend? in STEREO data (W12).                      |
| HD 46105        | NSV 16891              | VAR                  |                          | 0.793263(8)            |                 |                                                                                  |
| HD 46649        |                        |                      |                          | 4.1792(3)              |                 | RM09: A0 Si Cr ? *                                                                |
| HD 49797        |                        |                      |                          | 1.22649(2)             |                 | Null result for roAp pulsations (Martinez & Kurtz 1994).                        |
| HD 50031        |                        |                      |                          | 2.8743(1)              |                 |                                                                                  |
| HD 51342        |                        |                      |                          |                        | Hackstein et al. (2015) | The CP2 star may not be the A component (RM09). *                                 |
| HD 296343       | GDS_J0705593-050617    | VAR n/a              |                          | 1.43601(2)             |                 |                                                                                  |
| HD 57368        |                        |                      |                          | 9.8306(9)              | Hackstein et al. (2015) |                                                                                  |
| HD 57964A       |                        |                      |                          | 3.5286(2)              |                 |                                                                                  |
| HD 61008        | NSV 17517              | VAR                  | 1.33237 (VSX)           | 2.66482(9)             | Koen & Eyer (2002) | R12: EB/SPB (prob: 0.15/0.57)                                                   |
| HD 62821A       | GDS_J0744549-250026    | VAR n/a              |                          | 3.8347(2)              | Hackstein et al. (2015) |                                                                                  |
| GSC 08911-01572 |                        |                      |                          | 5.5805(4)              |                 |                                                                                  |
| HD 66051        | V414 Pup               | EA+ACV               | 4.74922 (Otero 2003)    | 4.74922(1)             | Otero (2003)    | Synchronous rotation. ACV and EA period are the same. Amp. of rot. var. = 0.05 mag (Otero 2003). |
| HD 67909        |                        |                      |                          | 2.41433(8)             |                 | Null result for roAp pulsations (Martinez & Kurtz 1994).                        |
| HD 68250        |                        |                      |                          | 0.841212(9)            |                 |                                                                                  |
| HD 68322        |                        |                      |                          | 1.76642(3)             |                 |                                                                                  |
| HD 68781        |                        |                      |                          | 3.2112(1)              |                 |                                                                                  |
| Star          | Var. Desig. | Var. Type | Period (day) | Period (day) | Reference | Remarks/Comments |
|--------------|-------------|-----------|--------------|--------------|-----------|-----------------|
| HD 69728     |            |           |              | 1.63779(3)   |           | RM9: uncertain, which component is (weakly) Ap |
| HD 71034A    |            |           |              | 5.3998(4)    |           |                 |
| HD 72634     | HIP 41667   | VAR       | 0.93051 (VSX)| 0.93062(1)   | Koen & Eyer (2002) |                   |
| HD 72976     | HIP 41954   | VAR       | 3.85654 (VSX); 3.85656 (R12)| 3.8560(2) | Koen & Eyer (2002) | R12: SPB/ACV (prob: 0.31/0.40) |
| HD 72770     | ASAS J083344-2808.1 | ESD/EC | 4.7930 (VSX) | 4.7915(3) | Sitek & Pojmanski (2014) | R12: BCEP/DSCT (prob: 0.30/0.49) |
| CD-38 4858   | GDS J084644-383832 | VAR | n/a          | 9.6457(9)   | Hackstein et al. (2015) | Null result for roAp pulsations (Martinez & Kurtz 1994). |
| HD 76759A    |            |           |              | 1.20648(2)  |           |                 |
| HD 77809     |            |           |              | 2.37366(7)  |           |                 |
| CPD-59 1669  |            |           |              | 3.8271(2)   |           |                 |
| HD 91825A    |            |           |              | 2.7634(1)   |           |                 |
| HD 92315     |            |           |              | 1.57651(3)  |           |                 |
| HD 92384     |            |           |              | 2.29382(7)  |           |                 |
| HD 303209    |            |           |              | 1.60624(3)  |           |                 |
| HD 96204     |            |           |              | 3.5745(2)   |           |                 |
| HD 102454    | ASAS J114726-3115.3 | ED/ESD/SR | 4.1579 (Sitek & Pojmanski 2014) | 2.07906(5) | Sitek & Pojmanski (2014) | R12: BCEP/DSCT (prob: 0.30/0.49) |
| HD 106204    | NSV 19303   | VAR       |              | 4.3572(3)   | Rufenner & Bartholdi (1982) |                 |
| BD+01 2668   |            |           |              | 0.98410(1)  |           |                 |
| HD 109300    |            |           |              | 2.63189(9)  |           |                 |
| HD 110072    |            |           |              | 22.225(6)   |           |                 |
| HD 110274    | ASAS J124131-5855.4 | MISC | 265.3 (Freyhammer et al. 2008a) | 265.1(4) | Freyhammer et al. (2008a) |                 |
| HD 110568    |            |           |              | 310.0 (Sitek & Pojmanski 2014) | 9.6018(9) | Freyhammer et al. (2008a) |                 |
| HD 115398    |            |           |              | 0.72046(0)  |           |                 |
| HD 115226    | roAp       |           |              | 10.86 minutes (Kochukhov et al. 2008) | 2.9882(1) | Kochukhov et al. (2008) | Kochukhov et al. (2008) find $v \sin i = 25–30$ km s$^{-1}$ and $P_{\text{rot}} \leq 3.0–3.5$ day. Surface abundance inhomogeneities established. No variability found in ASAS data but marginal variability with $P = 3.61$ day in Hipparcos data. |
| HD 115440    |            |           |              | 5.4421(4)   |           |                 |
| HD 117096    |            |           |              | 2.12428(6)  |           |                 |
| HD 117692    |            |           |              | 3.2798(1)   |           |                 |
| HD 121142    |            |           |              | 1.69062(3)  |           |                 |
| HD 121661    | ASAS J135842-6243.1 | MISC | 47.0 (Freyhammer et al. 2008a) | 46.86(2) | Freyhammer et al. (2008a) |                 |
| Star              | Var. Desig. Literature | Var. Type Literature | Period (day) Literature | Period (day) This work | Reference          | Remarks/Comments                  |
|------------------|------------------------|----------------------|-------------------------|------------------------|-------------------|-----------------------------------|
| HD 121841        |                        |                      |                         |                        | Freyhammer et al. (2008a) | Null results for roAp pulsations (Martinez & Kurtz 1994). |
| HD 122983        | ACV                    | 3.4 < P < 3.8 (Paunzen et al. 2011) |                         |                        | 1.08529(2)         | *                                 |
| HD 123164        |                        |                      |                         |                        | 3.61666(2)         | Paunzen et al. (2011)            |
| HD 124455        | HIP 69725              | VAR                  | 0.828705 (R12)          |                        | 5.9563(4)          | R12: BE+GCAS/DSCT (prob: 0.23/0.59) |
| HD 129724        | ACV                    | 3.55 (Paunzen et al. 2011) |                         |                        | 3.5487(2)          | *                                 |
| HD 129934        |                        |                      |                         |                        | 2.17566(6)         | *                                 |
| HD 130382        |                        |                      |                         |                        | 1.66901(3)         | *                                 |
| HD 131505A       | HIP 74294              | VAR                  | 0.758752 (R12)          |                        | 1.51763(3)         | R12: DSCTC/DSCT (prob: 0.24/0.24) |
| HD 136357        |                        |                      |                         |                        | 1.92479(5)         | *                                 |
| HD 137309        | HIP 69725              | VAR                  | 0.828705 (R12)          |                        | 5.9563(4)          | R12: BE+GCAS/DSCT (prob: 0.23/0.59) |
| HD 140532        | ACV                    | 3.9815 (W12)         |                         |                        | W12 blend?, weak signal (W12). |
| HD 144748        |                        |                      |                         |                        | 1.25143(2)         | *                                 |
| HD 149228        | HIP 74294              | VAR                  | 0.758752 (R12)          |                        | 1.51763(3)         | Constant or probably constant (W12). |
| HD 149334        | ASAS J163524-3400.8    | EA                   | 3.5444 (Sitek & Pojmański 2014) |                        | 3.54420(6)         | Sitek & Pojmański (2014)         |
| HD 149769        |                        |                      |                         |                        | 8.2422(8)          | Null result for roAp pulsations (Martinez & Kurtz 1994). |
| HD 150323        | NSV 20737              | VAR                  |                         |                        | 5.3777(4)          | Vogt & Faundez (1979)            |
| HD 155188        |                        |                      |                         |                        | 3.3334(2)          | Null result for roAp pulsations (Martinez & Kurtz 1994). |
| HD 158450        | NSV 22273              | VAR                  |                         |                        | 8.5239(8)          | Vogt & Faundez (1979)            |
| HD 167476        | NSV 24444              | VAR                  | 1.043999 (R12)          |                        | 2.3905(1)          | Constant or probably constant (W12). |
| HD 170054        |                        |                      |                         |                        | 0.97317(1)         | Hrivnak (1977)                  |
| HD 170836        |                        |                      |                         |                        | 5.2315(4)          | Blue straggler according to Hrivnak (1977); R12: BE+GCAS/SPB (prob: 0.27/0.48) |
| HD 170860A       | ACV                    | 0.9? (Paunzen et al. 2011) |                         |                        | 19.516(5)          | *                                 |
| HD 173361        | ACV                    | “variable” (Paunzen et al. 2011) |                         |                        | 1.38585(2)         | *                                 |
| HD 173361        | HIP 92215              | VAR                  | 1.93720 (VSX)           |                        | 1.93789(5)         | *                                 |
| HD 181549        |                        |                      |                         |                        | 0.831981(9)        | Koen & Eyer (2002)              |
| HD 193325        |                        |                      |                         |                        | 22.871(6)          | *                                 |
| HD 198918        | NP Del                 | ELL:                 | 3.153 day? (RM09)       |                        | 3.1529(1)          | *                                 |
| HD 200199        | NSV 25655              | VAR                  | 1.57594 (VSX)           |                        | 1.03512(1)         | van Leeuwen et al. (1997)        |
| HD 205013        |                        |                      |                         |                        | 1.57624(3)         | Kornilov et al. (1991)           |
Table 3
(Continued)

| Star        | Var. Desig. Literature | Var. Type Literature | Period (day) Literature | Period (day) This work | Reference | Remarks/Comments Literature |
|-------------|------------------------|----------------------|-------------------------|------------------------|-----------|-----------------------------|
| HD 209605A  |                        |                      |                         | 7.8132(7)              |           | Null result for roAp pulsations (Martinez & Kurtz 1994). |

Note. An asterisk in Column 7 ("Remarks/comments") denotes stars whose statuses as chemically peculiar objects are doubtful according to RM09. The following abbreviations are employed in Column 7: R12 = Rimoldini et al. (2012); W12 = Wraight et al. (2012).
properties of ACV variables, which will include results from the literature as well as our own investigations (Paper 1; Bernhard et al. 2015b, this paper). Therefore, in the present work, we restrict ourselves to the discussion of interesting and unusual objects.

4.2. Notes on Individual Objects

The following sections contain notes and literature information on several unusual and interesting objects.

4.2.1. CPD-20 1640 = NGC 2287 40

CPD-20 1640 is listed with a spectral type of A5pSiSr in the RM09 catalog. It has been identified with Cox 40 (= NGC 2287 40) and is likely a member of the intermediate-age open cluster NGC 2287 (Landstreet et al. 2007). However, its status as a CP2 star needs confirmation. While the listed spectral type is in accordance with this classification, it is not supported by the measured $D_a$ and $Z$ values and the non-detection of a magnetic field (see Landstreet et al. 2007, and references therein).

ASAS-3 data indicate that CPD-20 1640 is an eclipsing binary with a period of $P = 2.43400(2)$ days. The primary minimum is sharp and suggestive of a detached or semi-detached system (see Figure 4). If proven that at least one component of this system is indeed a classical CP2 star, CPD-20 1640 would be of high interest, as the incidence of CP2 stars in eclipsing binaries is very low (see Section 3.2). RM09 list only five candidates for eclipsing CP2 stars; only one (AO Velorum) has been confirmed (González et al. 2006). Another confirmed eclipsing CP2 star (HD 66051) is presented in the following section. One good candidate (HD 70817) and three possible candidates were identified in Paper 1 but need spectroscopic confirmation. We therefore strongly encourage further studies of CPD-20 1640 in order to confirm or reject the assumed presence of a CP2 star in the system.

4.2.2. HD 66051 = V414 Pup

HD 66051 is a confirmed CP2 star of the Silicon subgroup (Bidelman & MacConnell 1973; Houk & Smith-Moore 1988) and listed with a spectral type of A0pSi in the RM09 catalog. Its photometric variability was discovered in Hipparcos data (HIP 39229; van Leeuwen et al. 1997). The star was subsequently included in the GCVS as an ACV candidate (type ACV); no period or epoch were given.

The star was discovered to be an eclipsing binary of Algol-type (GCVS-type EA) by Otero (2003), who derived an orbital period of $P = 4.74922$ days and a magnitude range of $8.79–9.12$ mag $(V)$ from a combination of Hipparcos and...
ASAS-3 data. Furthermore, the star was shown to exhibit additional variability with an amplitude of 0.05 mag and the same period, which was interpreted as being due to “ACV variations,” i.e., rotationally induced variability caused by surface inhomogeneities on (at least) one of the system’s components.

No further detailed studies of HD 66051 exist in the VizieR and SIMBAD databases. However, a high-resolution spectrum of the star is available in the archive of the “Variable Star One-shot Project” (Dall et al. 2007), which was taken with the HARPS instrument (Mayor et al. 2003) at the ESO La Silla Observatory in Chile. Details on the spectroscopic observation can be found in Dall et al. (2007). The spectrum confirms that HD 66051 harbours a CP2 Si star (see Figure 5). In addition to that, enhanced lines of other elements, such as, e.g., Sr, Cr, and Eu, are present. The spectrum was obtained on JD 2453827.518802, which—assuming the epoch of 2452167.867 as orbital phase $\phi = 0$ (Otero 2003)—corresponds to $\phi_{\text{orb}} = 0.46$. The spectrum does not confirm the proposed SB2 nature of the system (Dall et al. 2007), which is likely due to coverage at an “unfortunate” orbital phase.

We have investigated the object using all available data and confirm the findings of Otero (2003). The longevity of the observed secondary variability in the light curve, which remains stable during the $\sim$9 years of ASAS-3 coverage (Figure 6), might be interpreted in terms of synchronous rotation, i.e., both stars are tidally locked.

HD 66051 is of great astrophysical interest. First, the incidence of eclipsing binaries among CP2 stars is very low (see Section 3.2). Second, the system is quite unique in exhibiting both eclipses and obvious rotational variability due to abundance inhomogeneities, which opens up a lot of interesting possibilities for future research. We have already embarked on a detailed study of this star, the results of which will be presented in a future publication.

4.2.3. HD 115226

Using time-series spectroscopy, Kochukhov et al. (2008) identified HD 115226 as a rapidly oscillating Ap (roAp) star and inferred a pulsation period of 10.86 minutes from radial velocity variations in Pr III, Nd III, Dy III, and the narrow cores of the hydrogen lines. They found $v_c \sin i = 25$–30 km s$^{-1}$ and deduced a rotational period of $P_{\text{rot}} \lesssim 3.0$–3.5 days. Furthermore, they established the presence of surface abundance inhomogeneities but did not detect any significant variability in the then available data from the ASAS-3 survey. However, marginal variability with $P = 3.61$ days and an amplitude below 0.01 mag was detected in Hipparcos data (van Leeuwen et al. 1997).

We have analyzed the available ASAS-3 data for HD 115226 and detect a clear signal at a frequency of $f = 0.33465$ c/d ($P = 2.9882$ days), which lies well above the noise level (Figure 7). The resulting phase plot shows a double wave, which is typical of ACV variables and consistent with both magnetic poles being visible over the rotation period (Figure 4). Furthermore, the derived period is in accordance with the above mentioned assumptions of Kochukhov et al. (2008).

We have investigated Hipparcos data and confirm marginal variability with $P = 3.61$ days, as proposed by the aforementioned authors. However, this signal is not present at all in the ASAS-3 data, which boast a much longer time base (3000 days) and a greater number of observations (639 measurements) than Hipparcos data ($\sim$1250 days; 116 measurements). We are therefore inclined to accept the period value derived from ASAS-3 data as real.

The pulsations of roAp stars are explained satisfactorily by the oblique pulsator model (Kurtz 1982; Saio 2005). Oblique pulsation results in frequency multiplets with components that are separated by the rotation frequency of the star (e.g., Takata & Shibahashi 1995). Thus, accurate knowledge of the rotation frequency is mandatory for the full interpretation of the frequency multiplets generated by the rotational modulation of the short period pulsations observed in roAp stars. The result of the present investigation will therefore provide a significant contribution to the deciphering of the frequency multiplet of the rapid, 10.86 minute oscillations observed in HD 115226.

4.2.4. HD 123884

RM09 indicated a spectral type of B8 He wk for this high-latitude early-type star, remarking, however, that the given spectral type is only an approximation and that the object apparently shows only hydrogen lines. Very disparate entries are found in the Catalog of Stellar Spectral Classifications (Skiff 2009–2016) which range from B4s to A0Ib? Bidelman (1988) called attention to HD 123884 and remarked that it might not be a classical CP star but rather a post-asymptotic branch star of moderate luminosity. Querying the SIMBAD and VizieR databases, no variability studies of the object were found.

ASAS-3 data indicate a period of $P = 1.02101(1)$ day for HD 123884. While the amplitude of variability is relatively high (0.013 mag, as derived with PERIOD04), the period value is close to one day; thus independent confirmation of our
results are needed. However, the resulting phase plot looks convincing (Figure 4) and shows indications of a double-humped structure, which is typical for ACV variables. Further studies to confirm the proposed variability and unravel the underlying mechanism are encouraged.

4.2.5. HD 149334

Bidellman & MacConnell (1973) give a spectral type of ApSr for this star, Houk (1982)—using exactly the same objective prism plates (Maitzen et al. 1997)—classified it as A9IV. Maitzen et al. (1997) found a ∆v value of +0.011 mag for HD 149334, which is below their peculiarity threshold of ≥0.014 mag.

HD 149334 was identified as an eclipsing binary system of Algol-type (GCVS-type EA) by Setike & Pojmanski (2014), who derived a period of P = 3.5444 days from ASAS I band data. An analysis of ASAS-3 V data confirms the results of the aforementioned investigators; because of the longer time base, the period could be refined to P = 3.5442(6) days (Figure 4).

Because the incidence of CP2 stars in eclipsing binaries is very low (see Sections 3.2 and 4.2.1), HD 149334 is a potentially interesting object. However, in the light of the conflicting results mentioned above, spectroscopic confirmation of the presence of a CP2 star in the system is needed.

4.2.6. HD 161733A = IC 4665 82

This star, which is likely a member of the open cluster IC 4665, is listed with a spectral type of B7 He wK C in RM09. In a detailed study of the object, Levato & Malaroda (1977) confirm the peculiar nature of HD 161733A and conclude that the star is a B-type peculiar object whose main peculiarities are being He weak; showing an enhancement of C and, perhaps, Fe and Ti; and the presence of Mn, P, Hg, and, possibly, Sr. They also find some evidence of variation in the C II λ4267 and Si II λλ4128–30 lines. We have not found a reference to a photometric variability study in the literature.

From an analysis of ASAS-3 data, we derive a photometric period of P = 0.97235(1) day (Figure 4). While the period value is close to one day, the significance of the detection and the amplitude of variability (0.02 mag, as derived with PERIOD04) are high. HD 161733 is a visual double star, the B component being of tenth magnitude and separated from the A component by 27″. Furthermore, the RM09 catalog indicates that HD 161733A is likely a spectroscopic binary characterized by a variable radial velocity and a supposed period of ~1.8 day, which is about twice our period value. Thus, further studies are required to decide whether the derived photometric period is caused by rotational or orbital modulation.

4.2.7. HD 186205

HD 186205 was identified as being a pronounced member of the class of He-rich stars by Walborn (1975). Lee & O'Brien (1977) confirmed Walborn’s results and derived Teff = 23,500 K, M/M⊙ = 12.3, R/R⊙ = 6.0, and log(L/L⊙) = 4.0—typical values for a He-rich star. On the basis of their data, they did not reach conclusive results about the presence of spectral variability in this star, which is listed with a spectral type of B3 He in the RM09 catalog. To the best of our knowledge, HD 186205 has never been confirmed as a photometrically variable star.

An analysis of ASAS-3 data indicates light variability with a period of P = 37.28(2) day. The resulting phase plot looks convincing (Figure 4), and the amplitude of variability is relatively high (~0.01 mag, as derived with Period04).

The timescale of the observed variability places the star outside the period domain of typical short-period, early-type pulsators, such as, e.g., the β Cephei variables. On the other hand, the observed variability is reminiscent of the PV Telescopii stars (GCVS-type PVTEL), subclass “PVTELL.” However, this class is reserved for hydrogen-deficient A or late-B supergiants, whereas HD 186205 is a confirmed dwarf star and does not show a pronounced hydrogen deficiency (Bougie et al. 1961; Walborn 1975).

Rotationally induced variability due to surface inhomogeneities might thus be the most promising explanation of the observed light changes, though orbital variability due to an as yet undetected companion star cannot be ruled out. Long-term spectroscopic monitoring of HD 186205 is needed to reach a final conclusion concerning the nature of the observed variability.

5. CONCLUSION

We have compiled an extensive target list of magnetic CP (CP2/4) stars from the General Catalog of Ap, HgMn, and Am stars (RM09). In addition to that, a systematic investigation of early-type (spectral types B/A) variable stars of undetermined type in the VSX yielded additional ACV candidates, which were included in our sample.

We investigated our sample stars using publicly available observations from the ASAS-3 archive. Employing a refined methodological approach, 360 stars exhibiting photometric variability in the accuracy limit of the ASAS-3 data were found. We thereby expand on a previous sample of 323 variable stars (Paper 1) and conclude our search for new photometrically variable magnetic CP stars in the ASAS-3 archive.

From an analysis of all available data, we conclude that our final sample is composed of 334 bona-fide ACV variables, 23 ACV candidates, and 3 eclipsing binary systems. We present summary data, folded light curves, and, if available, information from the literature for all our sample stars, and discuss interesting and unusual objects in detail. In particular, we call attention to HD 66051 (V414 Pup), which was identified as an eclipsing binary system showing obvious rotational modulation of the light curve due to the presence of an ACV variable in the system.

Further statistical analyses are presented in the present paper, but they will be given in a future publication that will include results from the literature as well as our own investigations (Paper 1, Bernhard et al. 2015b, this paper).

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Facilities: ASAS, AAVSO.
Software: Period04.
Figure 8. Light curves of all objects, folded with the periods listed in Table 2. The fit curves corresponding to the light-curve parameters given in Table 2 are indicated by the solid lines.

(The complete figure set (360 images) is available.)
