A Search for Photometrically Variable Magnetic CP Stars in Sky Survey Data

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Abstract

The magnetic chemically peculiar (mCP) stars of the upper main sequence are natural laboratories well-suited for the investigation of such diverse phenomena as e.g. atmospheric structure, magnetic fields and stellar rotation. We here present our efforts towards increasing the sample of known mCP stars by using publicly available photometric time series data, which has already led to the discovery of more than 850 photometrically variable mCP stars and candidates. We give an overview over previous results, outline future research projects and touch on some interesting finds that have led (or will lead) to follow-up investigations.

Introduction

Chemically peculiar (CP) stars make up about 10 % of upper main-sequence stars (spectral types early B to early F). They are characterized by peculiar atmospheric abundances that differ significantly from the solar pattern. The CP2 (Bp/Ap) stars and the CP4 (helium-weak) stars (also referred to collectively as the magnetic CP or mCP stars) are set apart by the presence of strong, stable and globally-organized magnetic fields [1, 2]. They exhibit a non-uniform distribution of chemical elements on their surfaces, which leads to spectral and photometric variability with the rotation period. mCP stars exhibiting photometric variability are traditionally referred to as α^2 Canum Venaticorum (ACV) variables.

During recent decades, automated sky surveys have advanced to become the dominant data source in astronomy. An increasing number of surveys routinely produce high-quality photometric time-series data well suited to the investigation of stellar variability. We have taken advantage of these data in the identification and investigation of new ACV variables and here present an overview over the present state of our project.

Methods

Two different approaches were taken, as outlined below. As our main aim is the discovery of *new* ACV variables (and thereby obtaining accurate rotation periods), objects already announced as such in the literature have been dropped from our sample.

- mCP stars from the Catalogue of Ap, HgMn, and Am stars [3] were selected and cross-matched with archival sky survey data.
- A search for the typical variability pattern of ACV variables was carried out among the light curves of early-type (spectral types B/A or colour-selected) variable stars of undetermined type in the AAVSO International Variable Star Index (VSX) [4].

Results

Following the methodology outlined above, we have established light variability in a large number of mCP stars not hitherto known as photometric variables. An overview over our results is presented in Table 1. An exemplary light curve is illustrated in Figure 1.

Table 1: New photometrically variable ACV stars and candidates, as derived from diverse sky survey data.

Data Source	#ACVs	Ref.
All Sky Automated Survey (ASAS)	316	[5]
	357	[6]
SuperWASP (SWASP)	80	[7]
KELT Transit Survey	49	[unpublished]
Kepler (also K2 mission)	>50	[unpublished]
total of new variables	852+	

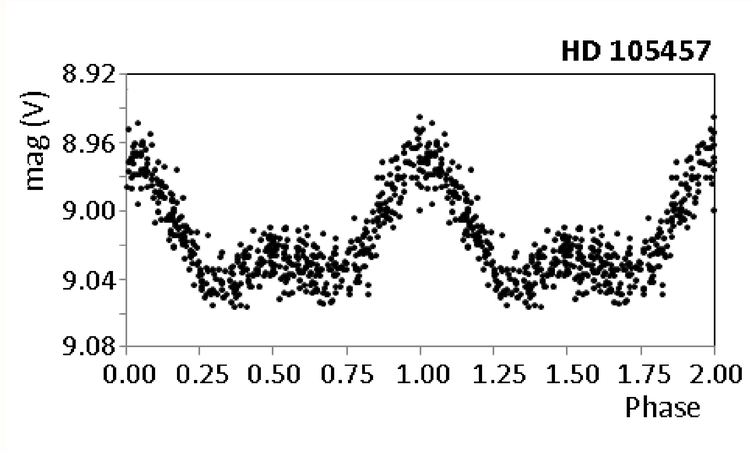

Figure 1: ASAS-3 light curve of HD 105457 (A0pSi, [3]).

Among these stars, several groups of interest have been identified which deserve special attention:

- **Eclipsing binary systems**: We have identified 14 eclipsing binary systems hosting an mCP star component (Figure 2). A lack of close binaries is generally observed among mCP stars; therefore, this finding is of great interest.
- **Pulsating stars**: We have identified several stars exhibiting variability on time-scales typical of δ Scuti variables (periods between about 15 minutes and 5 hours [8]) (Figure 3). While most of these stars are actually non-magnetic CP1 (Am) stars, several mCP star candidates are present. Spectroscopic verification, however, is needed and under way.

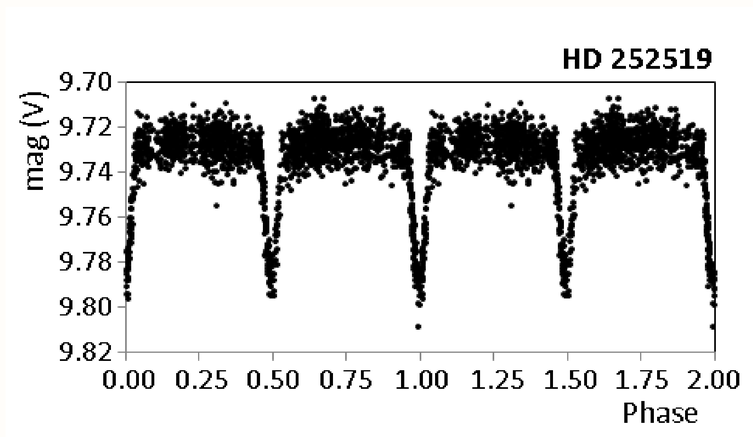

Figure 2: KELT light curve of HD 252519 (A1pCrSi, [3]).

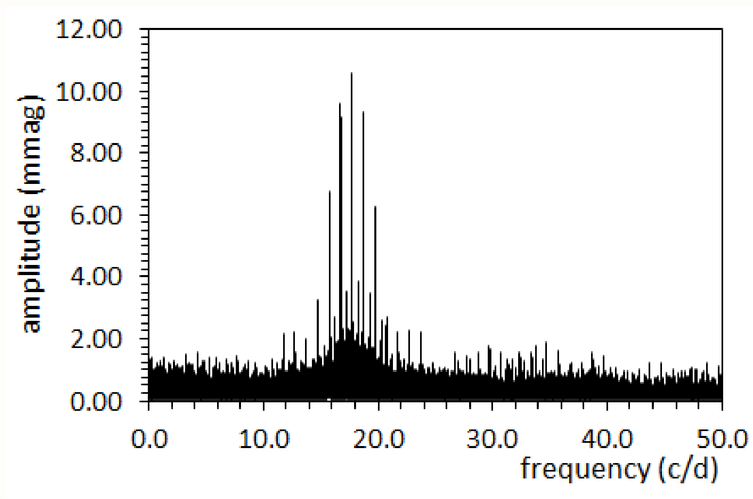

Figure 3: Frequency spectrum of SWASP data for HD 179259 (A8pEuCr?, [3]).

- **Miscellaneous objects of interest**: Some objects of special interest have been found, as e.g. HD 66051. This star – hitherto classified as a CP2 Si star – has been identified as an eclipsing binary system hosting a highly-peculiar CP3(HgMn)-related star (Figure 4). Obvious out-of-eclipse variability is present in the light curve, which we interpret as a signature of surface inhomogeneities on one of the components [9].

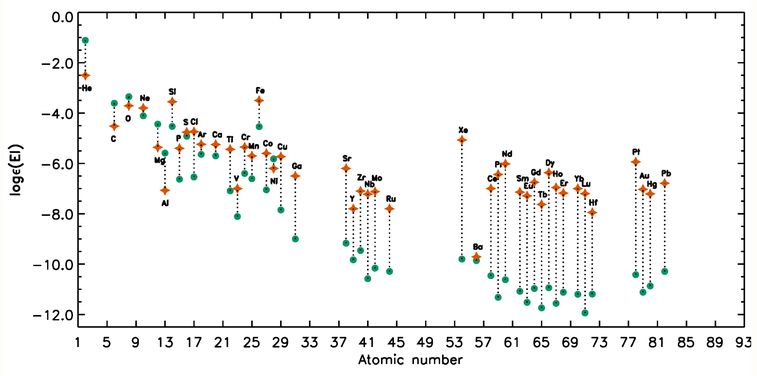

Figure 4: Comparison of the chemical composition of HD 66051 (orange stars) to the solar abundance pattern (green circles) [9].

Outlook

Some future research fields deriving from our main project are outlined in the following.

- Extension of the search for new ACV variables to other photometric survey databases (e.g. MOST).
- Spectroscopic confirmation of the 'photometric' ACV candidates. First results have shown that this might be a viable and efficient means of discovering new mCP stars (cf. the poster presentation by I. Yakunin et al.).
- Datamining of spectroscopic survey archives (LAMOST and SDSS) for new mCP stars.
- Search for very long-period ($P > 1$ yr) ACV variables in survey data. There exists a population of very slowly rotating objects among the mCP stars, with periods on the order of years, decades or even centuries [10]. A search for these objects requires alternative period search methods, which are currently under investigation.
- Investigation into the properties of the mCP stars that do not show photometric variability in the accuracy limit of the employed sky survey data.

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