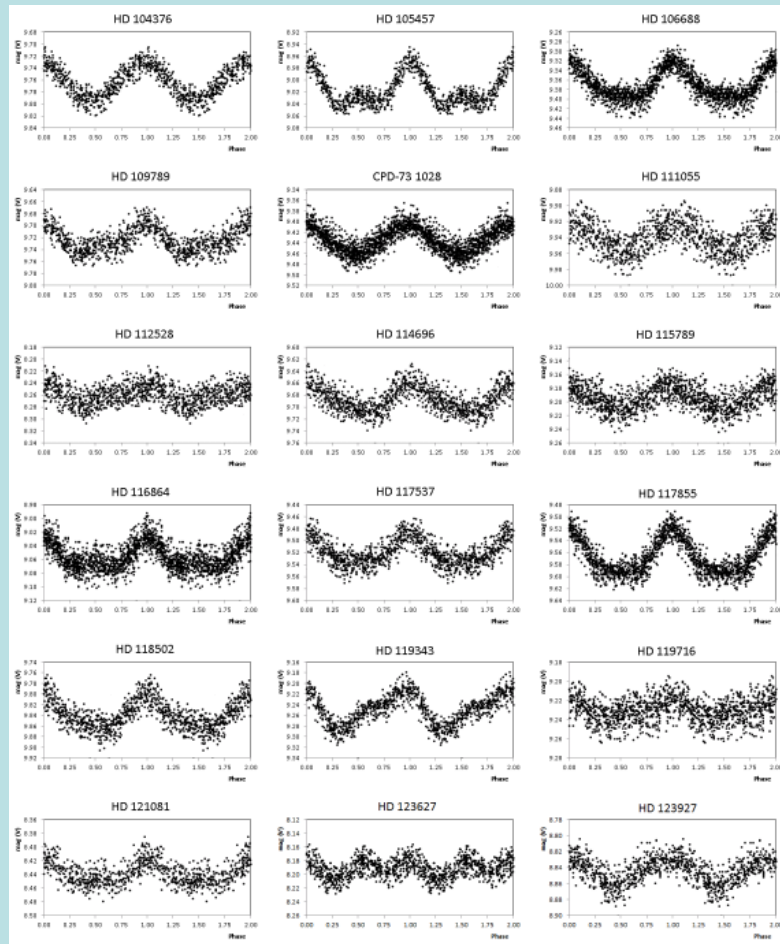


Neue $\alpha 2$ CVn Veränderliche aus den ASAS und SuperWASP Datenbanken

Klaus Bernhard
Stefan Hümmerich



Einführung: chemisch pekuliare Sterne

- Chemisch pekuliare Sterne (CP) sind Objekte der oberen Hauptreihe (Spektralklassen „early B to early F“) mit abnormal starken (oder schwachen) Absorptionslinien, die auf besondere Elementkonzentrationen an der Sternoberfläche hinweisen.

- etwa 10-15% der oberen Hauptreihe

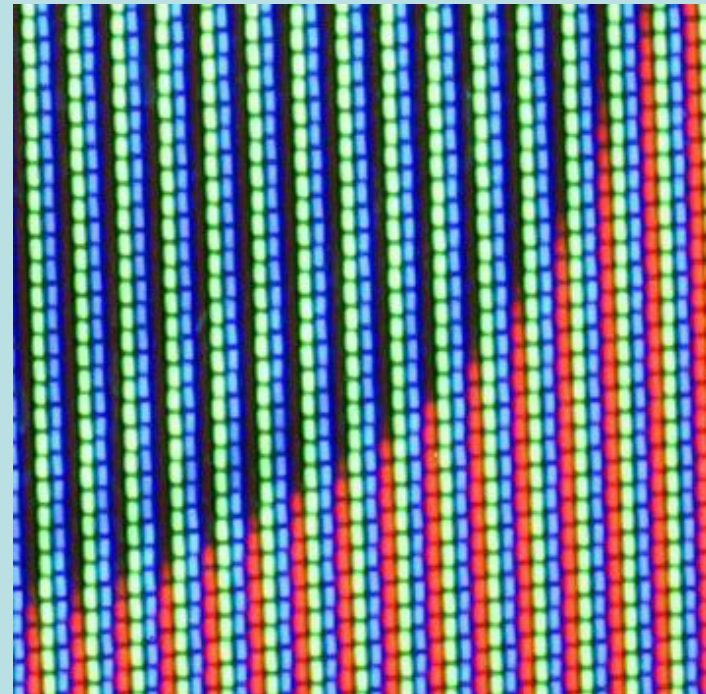
- 4 Klassen (Preston 1974):

- metallic line (or Am) stars (**CP1**)

- magnetic Ap stars (**CP2**)
Überhäufigkeit von Si, Cr, Sr, Eu

- HgMn stars (**CP3**)

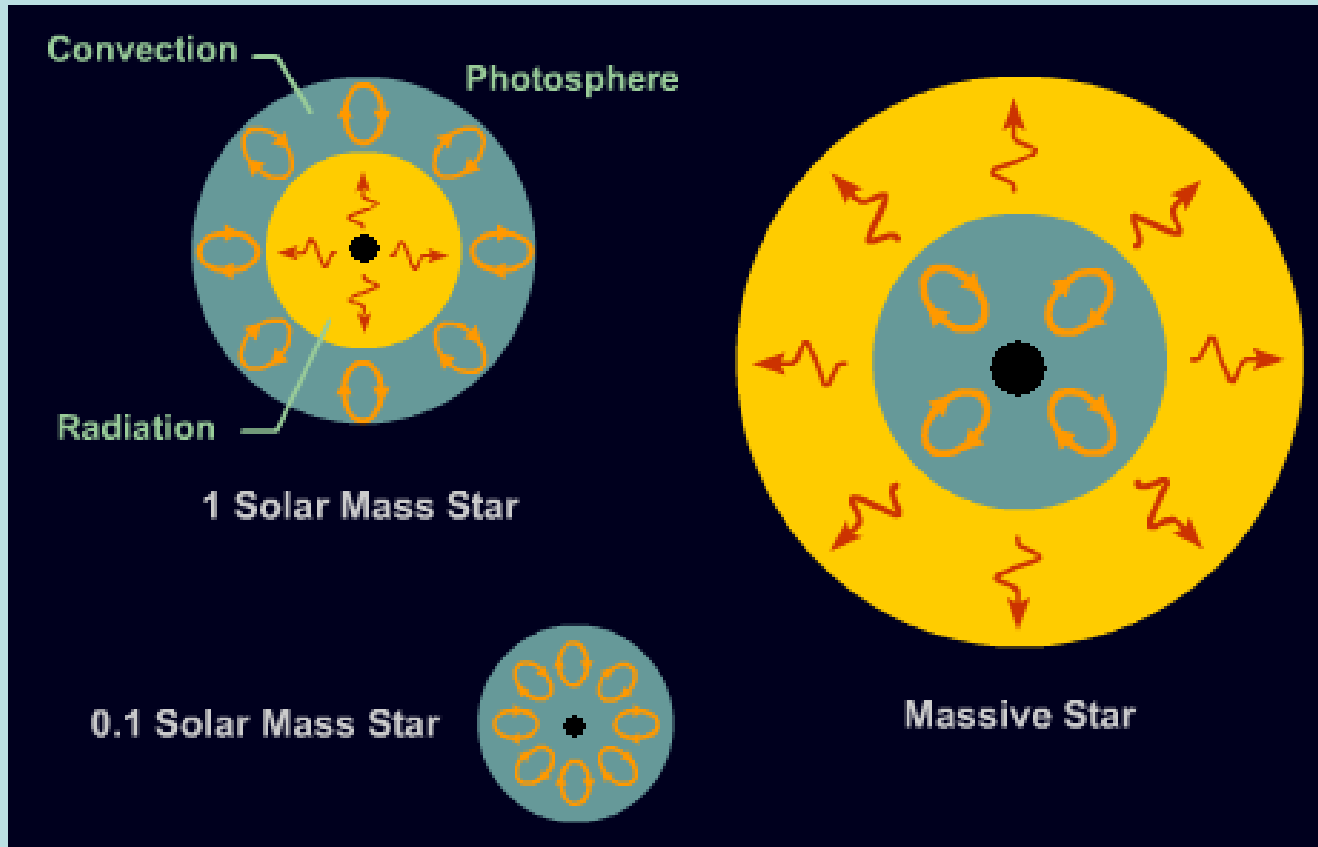
- He-weak/strong stars (**CP4**)



Eu: Europium (enthalten z. B. in
Bildschirmpigmenten)

Ursachen der Pekularität:

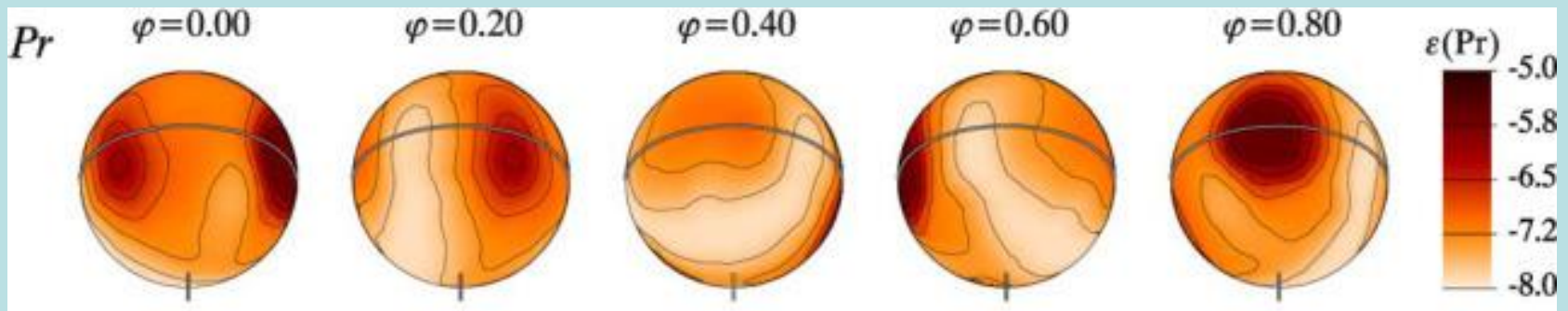
Vorbedingung rein radiativer Mantel; langsame Rotation



→ Diffusion von chemischen Elementen abhängig vom Gleichgewicht der Gravitation und Strahlungsdruck durch Absorption in Spektrallinien (Michaud 1970)

Interessante Fakten zu veränderlichen CP2 = α^2 Canum Venaticorum (ACV) Sternen

- ungleichmäßige Verteilung der chemischen Elemente an der Oberfläche, bedingt durch starke Magnetfelder
- "Oblique rotator model" (Stibbs 1950): Photometrische Periode ist Rotationsperiode
- Amplituden: 0.01 to 0.1 mag, Perioden i.d.R. 0.5 bis 160 Tage, aber auch 5 Jahre und länger



Suche nach ACV Sternen in ASAS und SuperWASP



ASAS



SuperWASP

Vorgangsweise

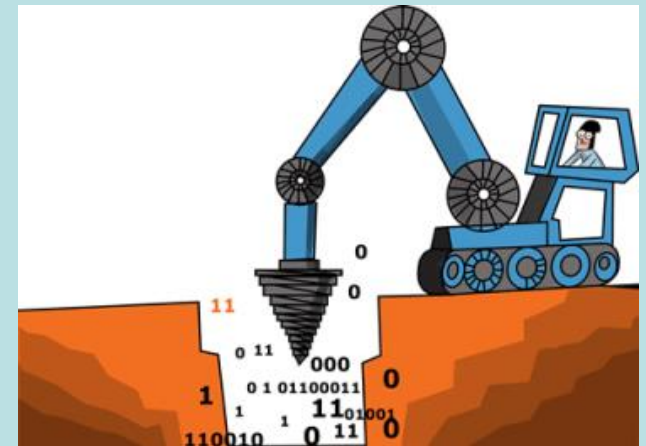
Input:
Catalogue of Ap, HgMn and Am
stars (Renson & Manfroid 2009)

Datenquelle 1:
The All Sky Automated Survey
(ASAS)

Datenquelle 2:
SuperWASP



neue ACV
Veränderliche



The All Sky Automated Survey (ASAS)

- "Low cost project" für photometrisches Monitoring des gesamten Südhimmels sowie Teilen des Nordhimmels ($\delta < +28^\circ$)
- Daten der 3. Projektphase (ASAS-3; 2000 – 2009) online
- Gute Photometrie für 10^7 Sternen im Bereich $7 < V < 14$ mag
- besonders genaue Photometrie im Bereich von $8 < V < 10$ mag
- geeignet auch zur Suche nach Mikrovariablen (4-5 mmag, e.g. Pigulski 2014)



ASAS telescopes, Las Campanas, Chile; source: ASAS homepage

Methoden

ASAS All Star Catalogue

Provides light curves for objects south of declination +26 deg, during years 2000-2009 (ASAS-3) and 1998-2000 (ASAS-2).
We are working on making new observations public (ASAS-3N located in the northern hemisphere and ASAS-4, observing since early 2010).

ASAS (asas3) Catalog Query Results (15")

#	ID	mag	err	Strobe
1	063022+0839.6	8.719	0.035	471
2	063021+0839.8	9.804	0.000	1
3	063022+0839.5	8.782	0.013	5
4	063022+0839.4	8.730	0.048	4

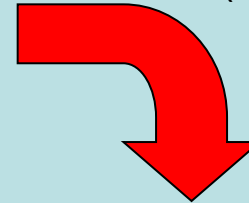
ASAS 063022+0839.6 Light Curve (asas3)

Source: α -band (ASAS-3) δ -band (ASAS-2) Equinox: 2000
RA: 22 29 49.3638 (RAJ2002+0839.6) N: 4
Dec: 08 39 14.50 r: 15 arcsec

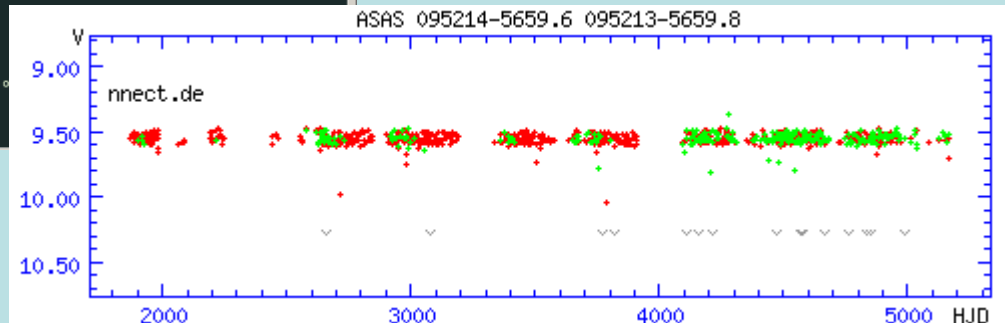
To access photometric data enter object ID's (one per line) in the area above. Valid identifications are: RA[h] DEC[deg] for example: 5.45 -81.5 or 5.26.50,-81.35:12
ASAS ID for example: 052650-8135.2
GCVS ID for example: XX Dor

All stars within r arcsecs from center, having more than N measurements will be listed. To obtain a light curve click on the object ID.
For more information on the catalogues go to the [Catalogues](#) section.

Download der Lichtkurven von Renson&Manfroid (5000 Objekte)

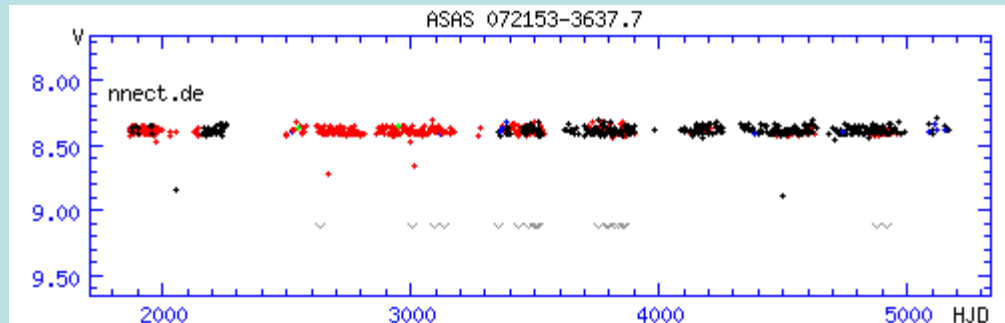


-Entfernung offensichtlicher Outlier

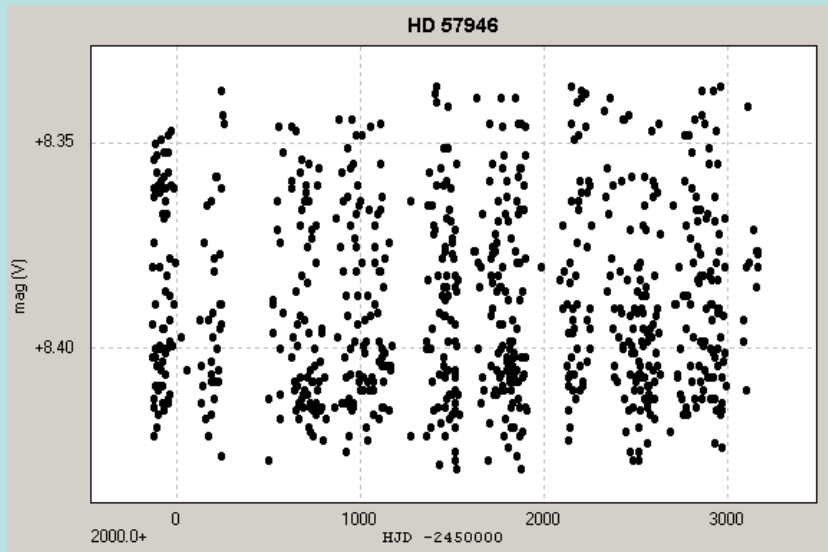


-Entfernung von Datenpunkten mit quality flag of "D" (=“worst data, probably useless”)

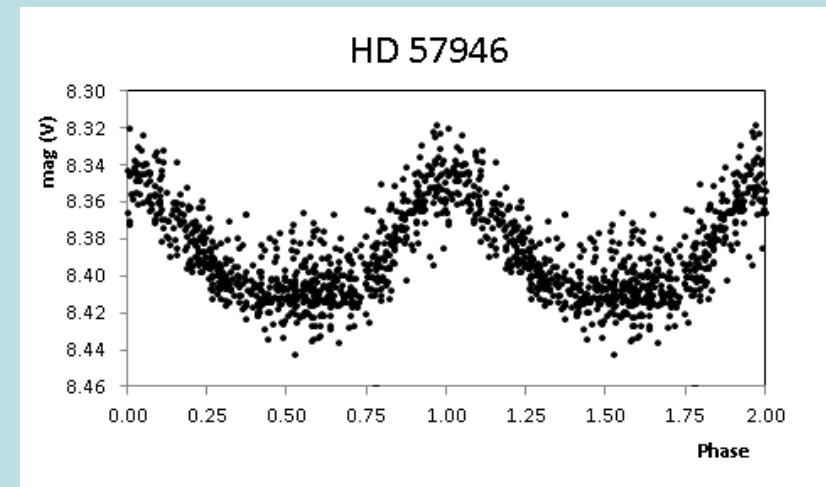
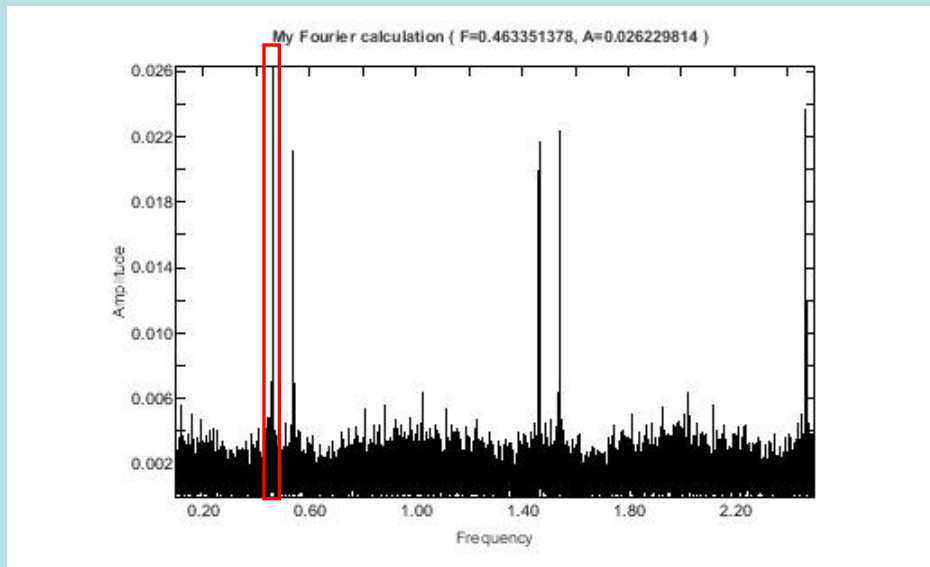
-Instrumentelle Trends



Periodenanalyse mit Period04 (Lenz & Breger 2005)



Achtung: häufig starke "daily aliases" in den Fourieranalysen!



Resultate: ASAS Sample

Type	Number of objects
Newly discovered ACV variables	239
Variables of undetermined type ¹	61
Misclassified variables ¹	16
EB/ELL star candidates	7
Whole Sample	323

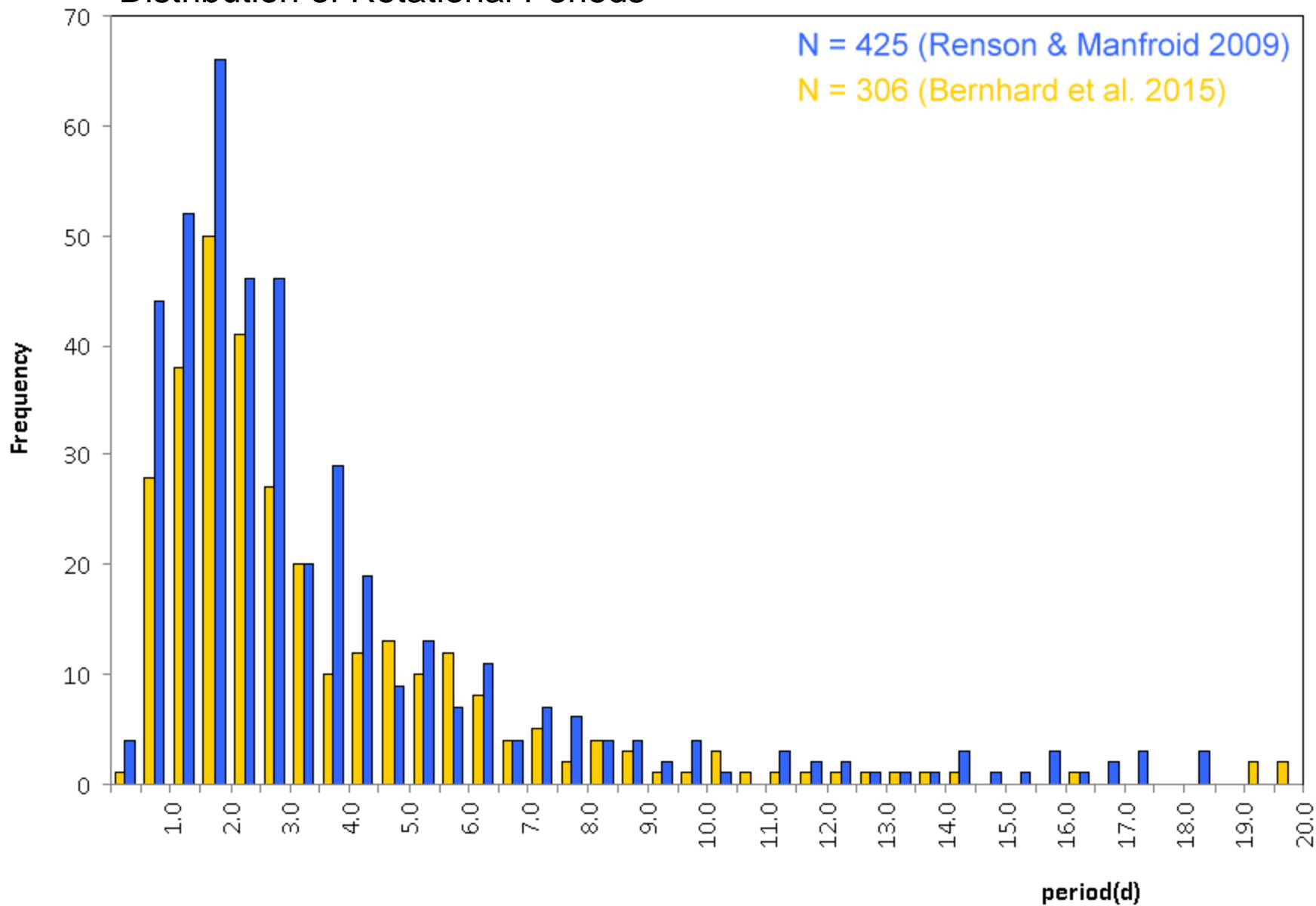
Notes: (1) Identified as ACV variables for the first time.

Table 1 - Statistical information on the sample
presented in A&A 581, A138 (2015)

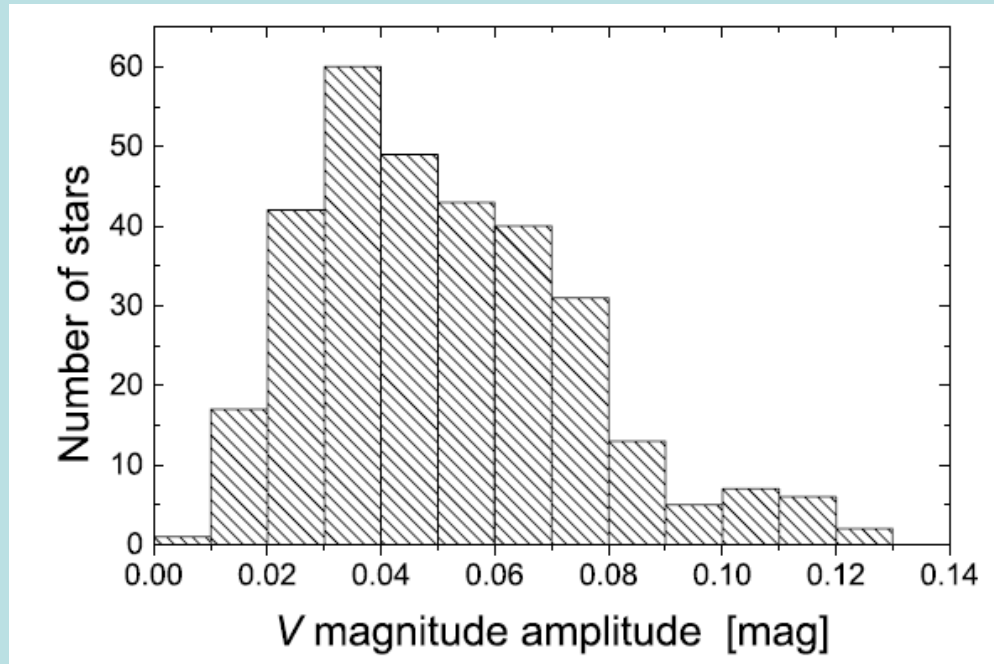
A search for photometric variability in magnetic chemically peculiar stars using ASAS-3 data

K. Bernhard, S. Huemmerich, S. Otero, E. Paunzen

Distribution of Rotational Periods



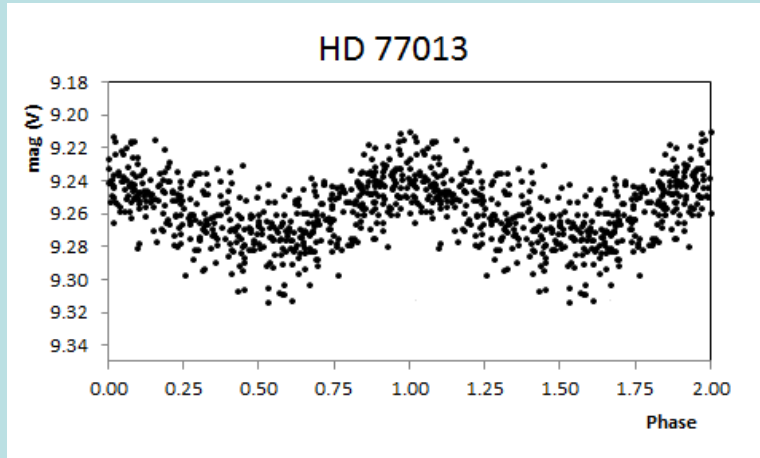
Verteilung der V-Amplituden



Gute Übereinstimmung mit Literaturdaten (e.g. Mathys & Manfroid 1985).

HD 77013 - a new record holder for the shortest period among CP stars?

(and, perhaps, the fastest rotator?)



mag range (V): 9.24 - 9.28

Period (d): 0.411738

spectral type (literature): A3

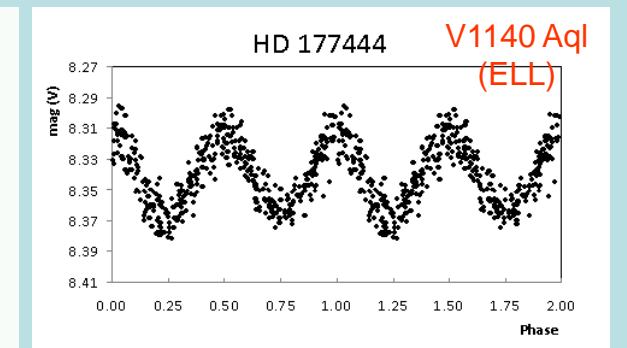
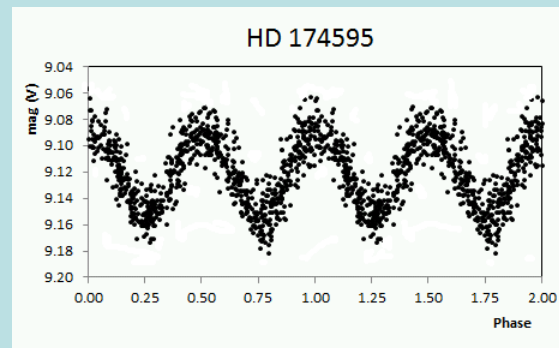
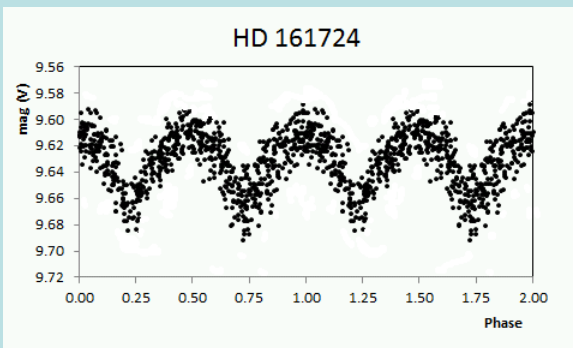
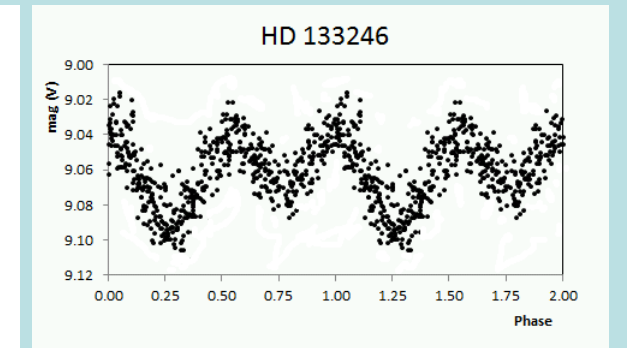
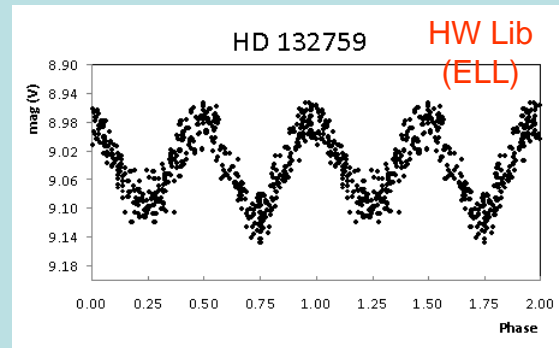
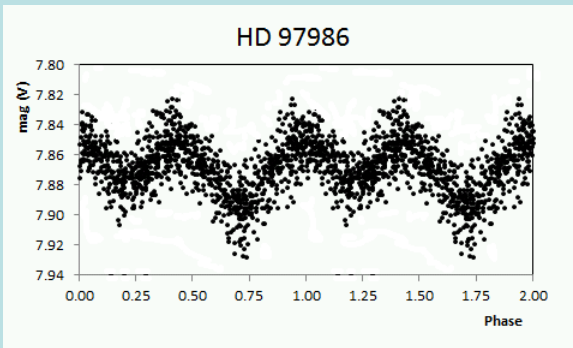
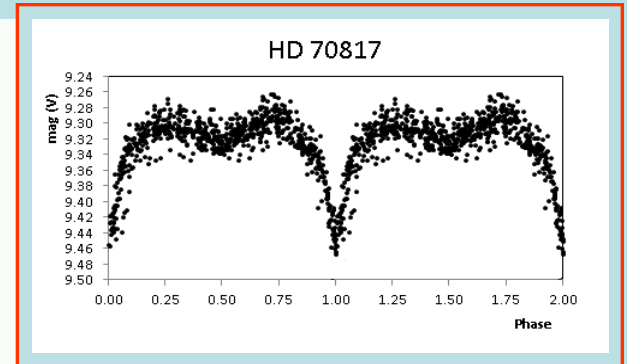
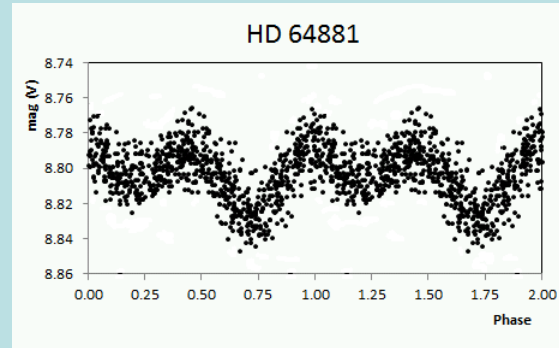
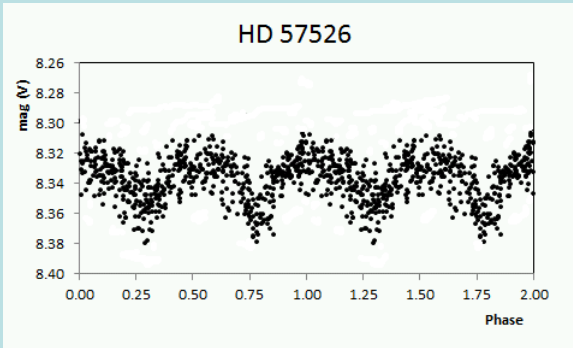
Some fast rotating CP stars (after Mikulášek et al. 2010):

- HD 164429 (P = 0.51899, Adelman 1999)
- HD 124224 = CU Vir (P = 0.52070, Sokolov 2000)
- **HR 7355 (P = 0.5214404, Koen & Eyer 2002)**
- HD 92385 (P = 0.54909, ESA 1997)

most rapid rotator among CP stars (Mikulášek et al. 2010)

EB / ELL candidates ($N = 7$)

only one confirmed eclipsing system comprising a CP2 star (AO Velorum; González et al. 2006)



(J-Ks) und (B-V) Indices versus logarithmische Rotationsperioden

Gibt es eine Korrelation, bisher Diskussion in der Literatur!

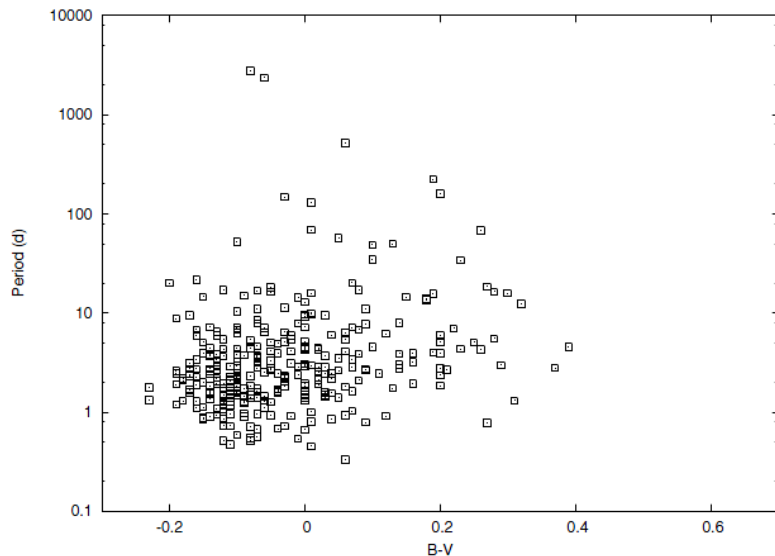


Fig. 8. Rotational periods of Ap stars as a function of $B - V$.

Renson & Manfroid (2009): no correlation between periods and (B-V) colours

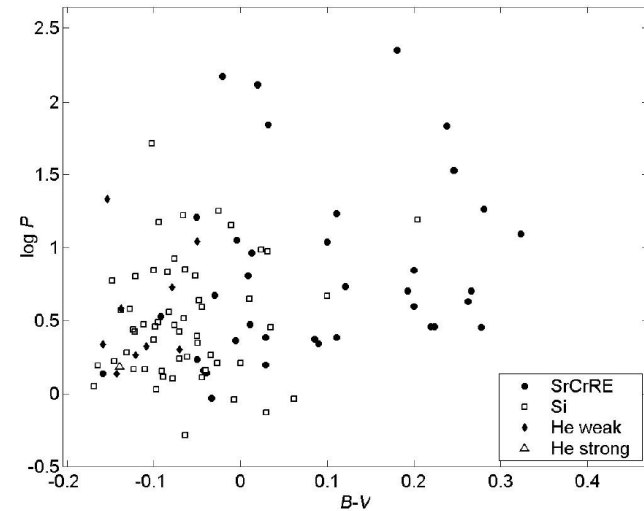
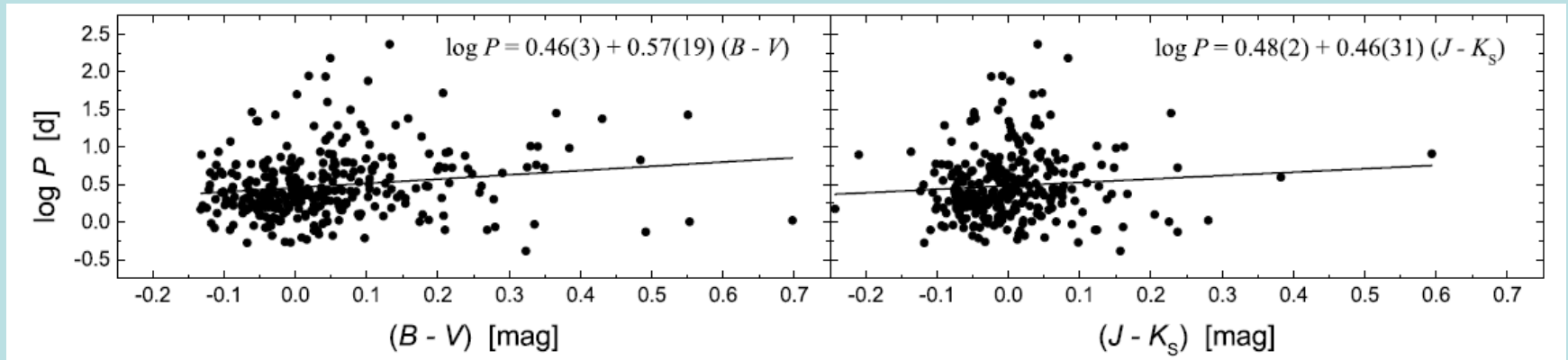


Figure 2. Dependency of common logarithm of the period in days on the B-V index with distinguishing various types of mCPod catalogue. It is apparent that cooler mCP stars rotate more slowly.

Mikulášek et al. (2009): cooler magnetic CP stars rotate more slowly

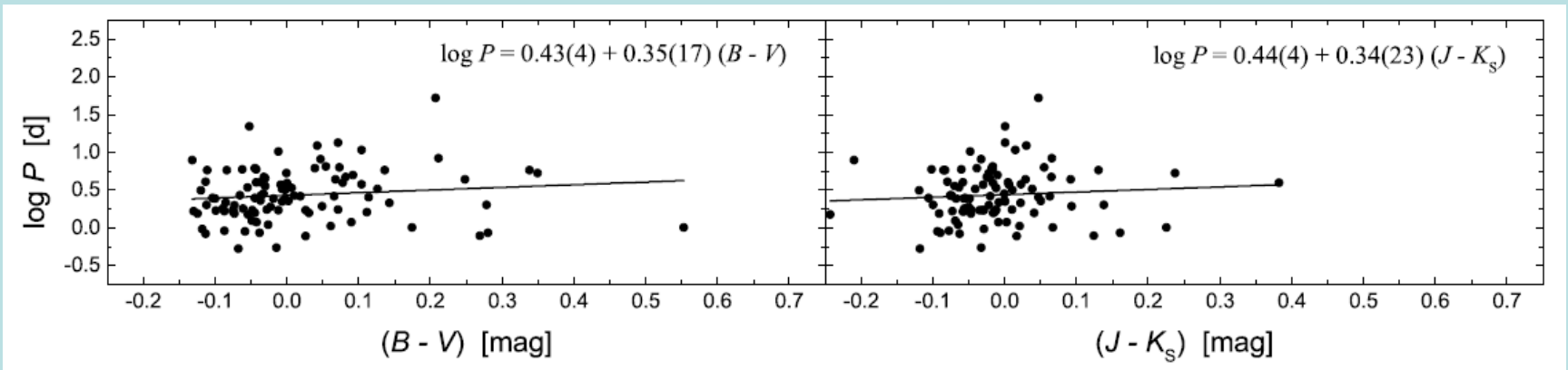
Mögliche leichte Korrelation auch in unseren Daten logP vs (B-V) bzw. J-Ks!



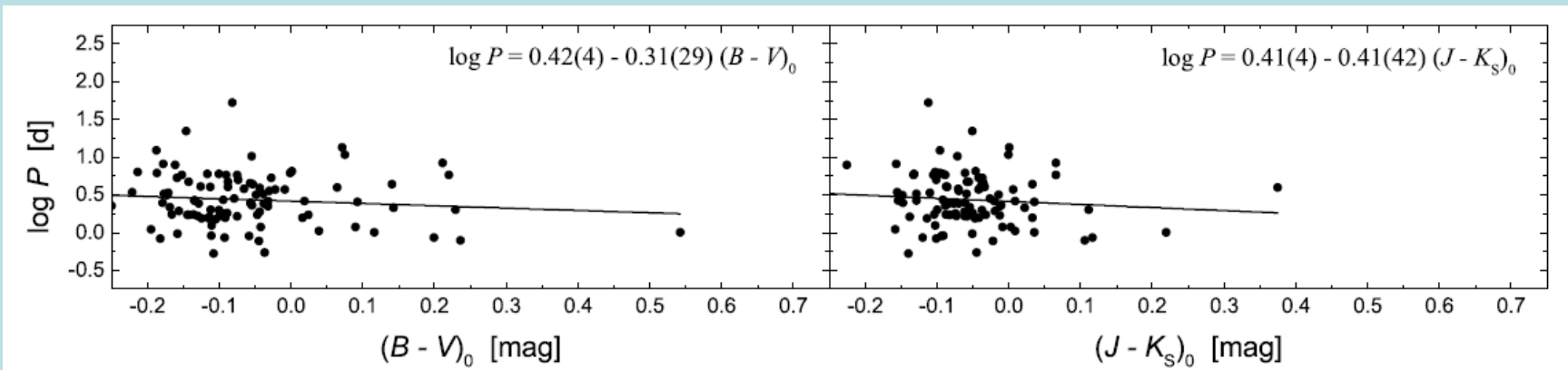
Rotational periods as a function of (B - V) and (J - K_s) of the photometrically variable Ap stars and Ap star candidates of the complete sample

Aber:

- "Reddening" ist nicht vernachlässigbar
- Meisten der Objekte in der Nähe der galaktischen Ebene.
- Reddening für 99 Objekte bestimmt A_V bis zu 1.5 mag.



reddened subsample → slopes slightly shallower but still significant



reddening-free subsample → no significant slope found for this data sample

SuperWASP

- Observatorio del Roque de los Muchachos (La Palma) und
- South African Astronomical Observatory (SAAO).
- Jeweils 8 f/1.8 200mm Canon Linsen und 2048 x 2048 Andor CCD Detektoren,
Feld $7.8 \times 7.8^\circ$ (CV)
- 18 Millionen geeignete Lichtkurven
8 - 14mag

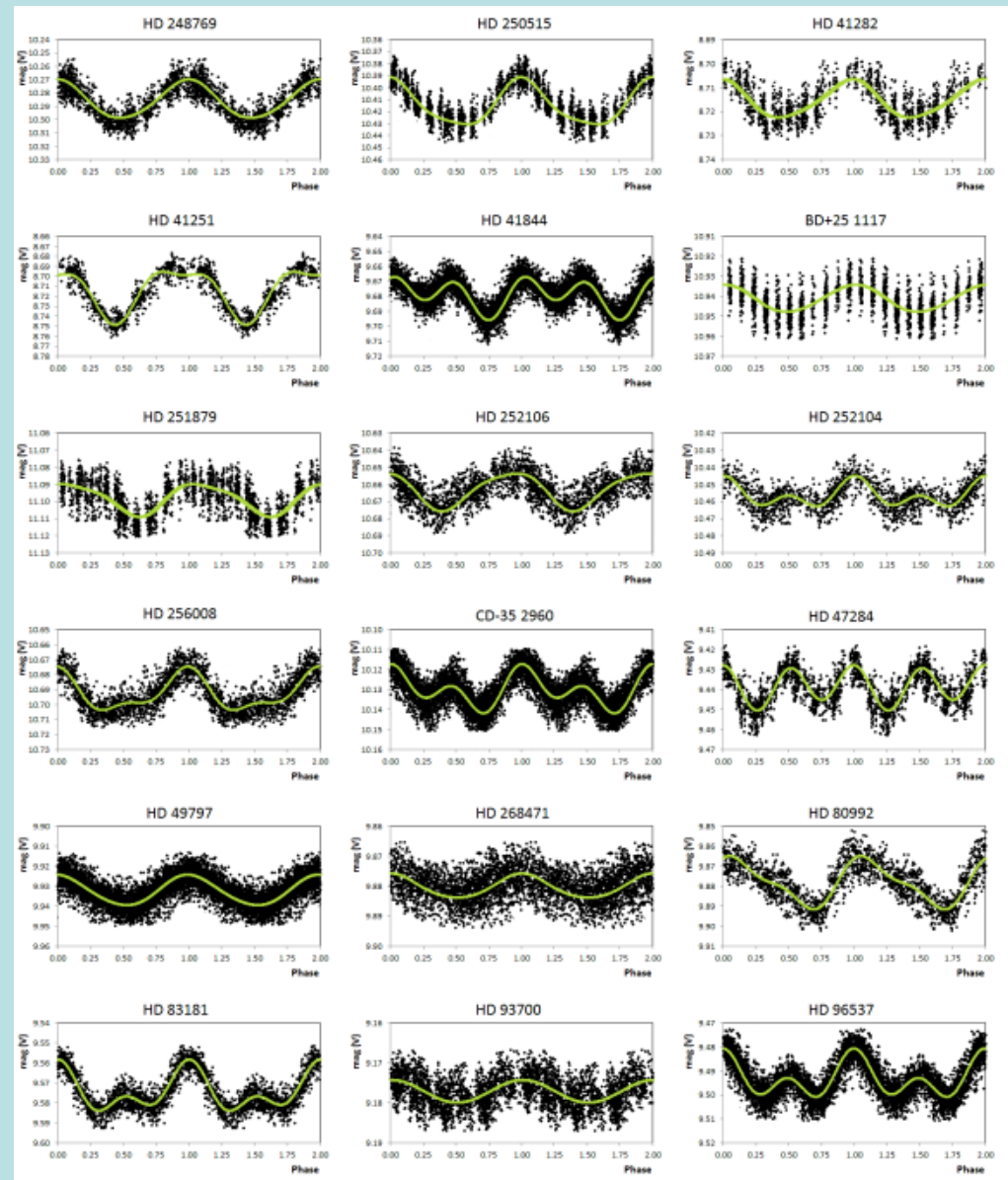


-Analyse von SWASP Daten

von ~600 stars from the Catalogue of Ap, HgMn and Am stars (Renson & Manfroid 2009)

-80 neue ACV Veränderliche

Bernhard, K., Hümmerich, S., Paunzen, E.,
Magnetic, chemically peculiar (CP2) stars in
the SuperWASP survey,
2015AN....336..981B



-ACV's bisher stiefmütterlich in der BAV behandelt?

Ausnahmen bestätigen die Regel!

-Interessante Aspekte, Periodenänderungen, B-V Antikorrelationen

HD 240121 - an ACV variable showing anti-phase variations of the B and V light curves

R. Gröbel¹, S. Hümmerich^{1,2}, E. Paunzen³ and K. Bernhard^{1,2}

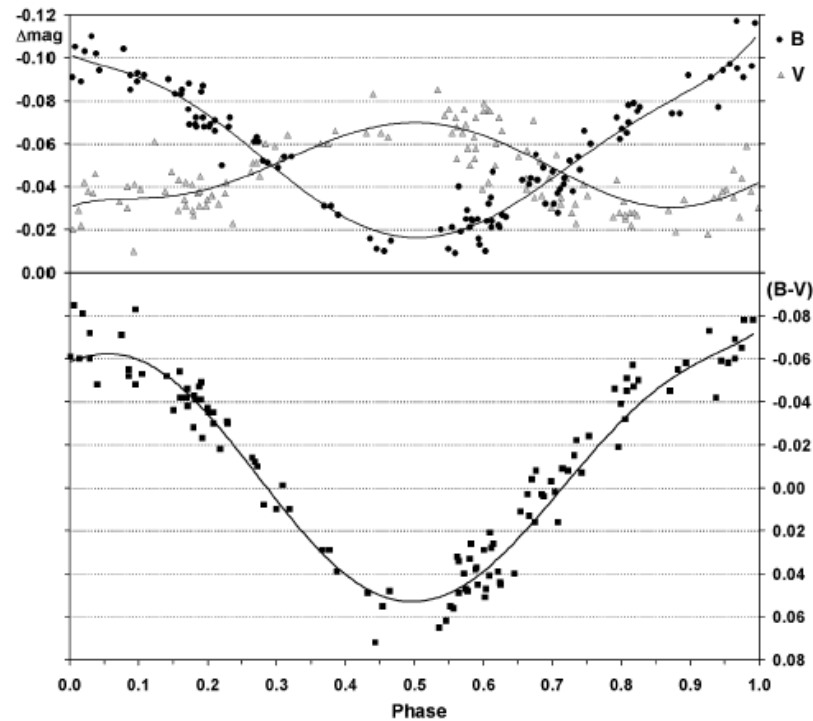
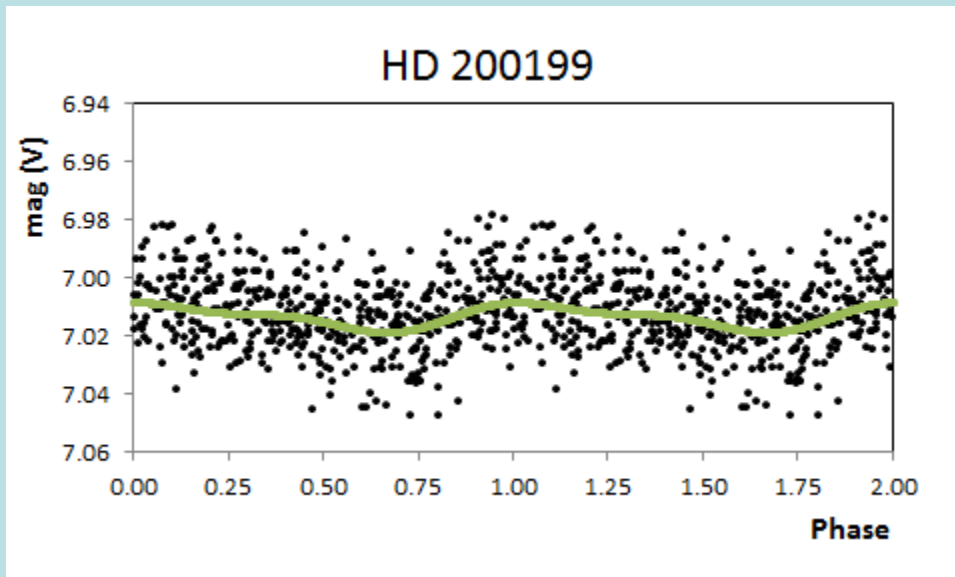
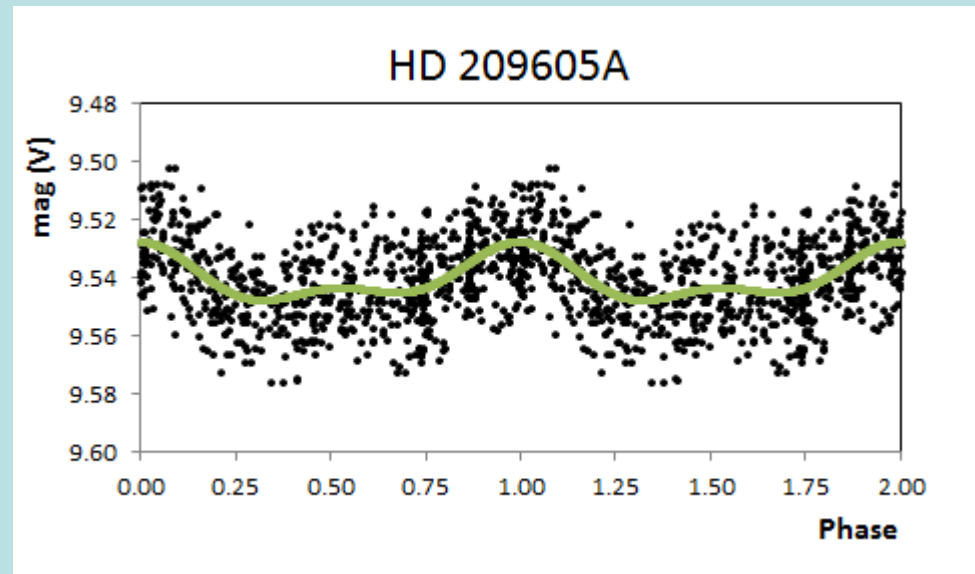


Figure 3: Folded light curves in B and V and the folded $(B - V)$ colour curve of HD 240121, based on the elements given in Equation (1). The solid lines indicate a 6th order polynomial fit to the data.

Ausblick

- Weitere Suche in ASAS: ~400 neue ACV Sterne
- Ausweitung auf andere Datenbanken und andere Suchmethoden (ohne Renson Liste)



Weitere ACVs
schlummern noch in
den Datenbanken!