Variable Star and Exoplanet Section of Czech Astronomical Society and Brno Observatory and Planetarium

Proceedings of the 44th Conference on Variable Stars Research

Brno Observatory and Planetarium, Brno, Czech Republic, EU

2nd – 4th November 2012

Editor-in-chief **Radek Kocián**

Participants of the conference in front of the observatory

TABLE OF CONTENTS

INTRODUCTION

Each year in November, when the full moon makes variable star observing difficult, the Variable Star and Exoplanet Section of Czech Astronomical Society holds a national conference on variable stars, stellar astrophysics in general and on extrasolar planets. Our conferences on variable star research provide unique opportunities for meetings between professional and amateur astronomers and have become a crucial platform for exchanging information and sharing knowledge.

This year is especially significant for us. After several years, the conference returned to the Brno Observatory, to a place which was the birthplace and center of modern history of variable stars observations in our country.

I would like to express gratitude to all authors for their talks and posters, to all participants for their contribution to the discussions and to the current director of the observatory Jiri Dušek for the opportunity to hold a conference at the Brno Observatory.

Luboš Brát
- president of Variable Star and Exoplanet
Section of Czech Astronomical Society
Pec pod Sněžkou, November 21st 2012

NOTES

The scientific content of the proceedings contributions was not reviewed by the OEJV editorial board.

OPEN EUROPEAN JOURNAL ON VARIABLE STARS
November 2012 http://var.astro.cz/oejv ISSN 1801-5964

Five eccentric eclipsing binaries with the relatively short periods of apsidal motion

H. KUČÁKOVÁ [1], M. WOLF [2]

(1) Observatory and Planetarium of Johann Palisa, VŠB-TUO, 17. listopadu 15, 708 33 Ostrava-Poruba, Czech Republic, hana.kucakova@centrum.cz
(2) Astronomical Institute, Faculty of Mathematics and Physics, Charles University in Prague, V Holešovičkách 2, 180 00 Praha 8, Czech Republic, wolf@cesnet.cz

Abstract: This text is focused on some information and results of the analysis of the selected eccentric eclipsing binaries with relatively short periods of apsidal motion - V785 Cas, V821 Cas, V796 Cyg, V398 Lac, and V871 Per. Further and more detailed information can be found in the paper in A&A (M. Wolf et al. 2013).

Abstrakt: Tento článek je zaměřen na některé informace a výsledky analýzy vybraných excentrických zákrytových dvojhvězd s relativně krátkými periodami apsidálního pohybu - V785 Cas, V821 Cas, V796 Cyg, V398 Lac a V871 Per. Další a podrobnější informace lze nalézt v článku v A&A (M. Wolf et al. 2013).

The five detached eclipsing systems with the eccentric orbits are relatively bright objects, so they are a good target for small or moderate telescopes. Observatories in the Czech Republic, where new CCD photometry observations of times of minimum light for the five eccentric eclipsing binaries were obtained:

- Ondřejov Observatory
- Observatory and Planetarium of Johann Palisa, VŠB-TU Ostrava
- Observatory and Planetarium Hradec Králové
- Observatory Valašské Meziříčí
- Private observatory of P. Svoboda, Brno
- Private observatory of M. Zejda, Brno

Monitoring of eccentric eclipsing binaries is a long-term observational project. The apsidal motion was studied by means of an O−C diagram analysis.

V785 Cas (*GSC 4041 0465, R.A.= 02^{h}10^{m}49^s.89 DEC.= +64°49'45".06 Equinox: 2000.0*)

(type EA, period 2.70 day, eccentricity 0.09, amplitude 9.33 – 9.64 mag)

V785 Cas was discovered by the Hipparcos project. Apsidal motion is rapid – 83 years.

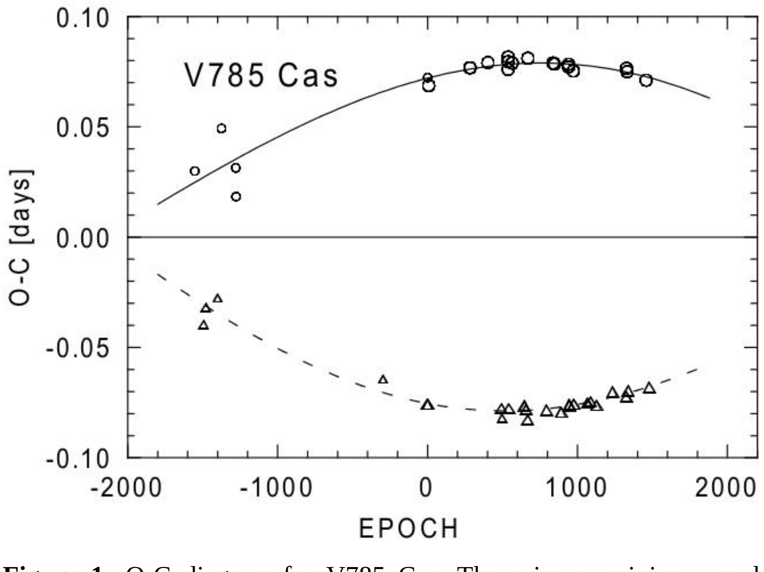

Figure 1: O-C diagram for V785 Cas. The primary minima are denoted by circles, secondary minima by triangles. Larger symbols (minima obtained by the photoelectric or CCD measurements) have higher weights in the calculations. The continuous curve represents predictions for the primary eclipses, dashed curve predictions for the secondary eclipses.

V821 Cas (*GSC 4001 1445, R.A.=* $23^h58^m49^s.17$ *DEC.= +53°40'19".81 Equinox: 2000.0*)

(type EA, period 1.77 day, eccentricity 0.14, amplitude 8.22 – 8.66 mag)

V821 Cas was discovered by S. Otero (from Hipparcos and NSVS data). Apsidal motion period *U* = 141 years.

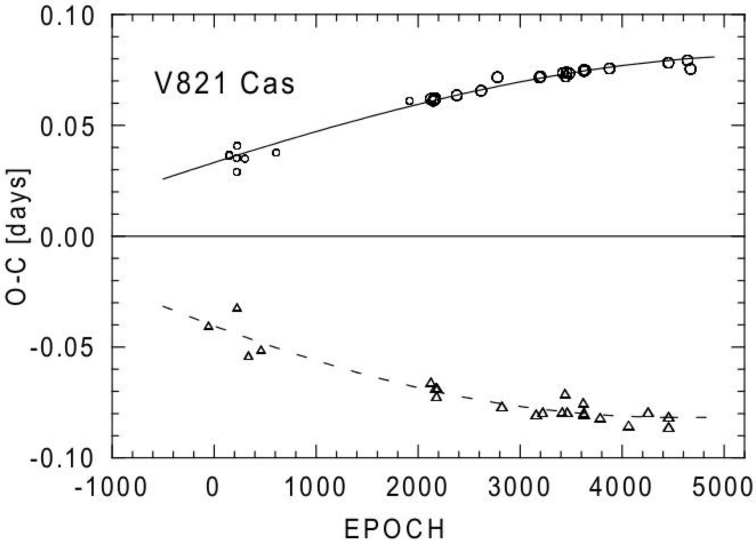

Figure 2: O-C diagram for V821 Cas.

V796 Cyg (*GSC 3560 0777, R.A.=* $19^h33^m56^s.11$ *DEC.= +47°18'34".19 Equinox: 2000.0*)

(type EA, period 1.48 day, eccentricity 0.07, amplitude 10.9 – 11.4 mag)

This binary system was discovered by Hoffmeister and later independently by Strohmeier. Because of the large scatter of the older data, only the new data (after the epoch –5000) were used for the apsidal motion solution. V796 Cyg has a rapid apsidal motion - only 33.3 years.

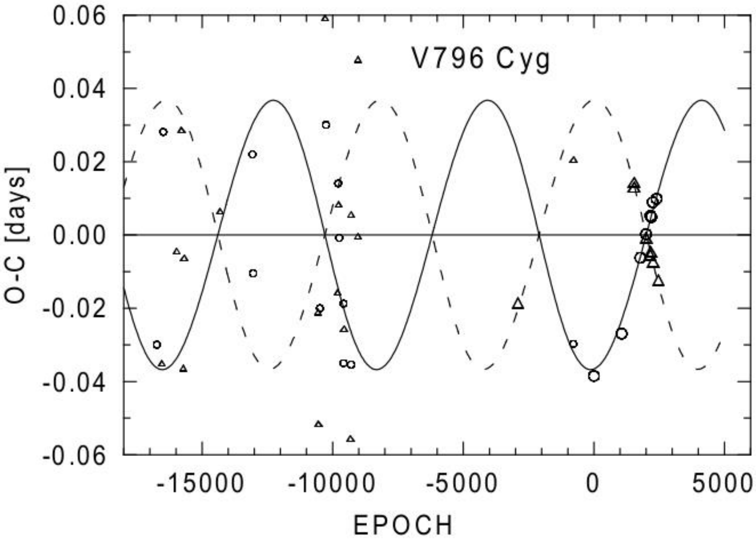

Figure 3: O-C diagram for V796 Cyg.

V398 Lac (*GSC 3969 1626, R.A.= 22^{h}07^{m}12^s.41 DEC.= +52°38'08".46 Equinox: 2000.0*)

(type EA, period 5.41 day, eccentricity 0.23, amplitude 8.73 – 9.02 mag)

Variability of V398 was discovered by Hipparcos. Apsidal motion is slow - 437 years.

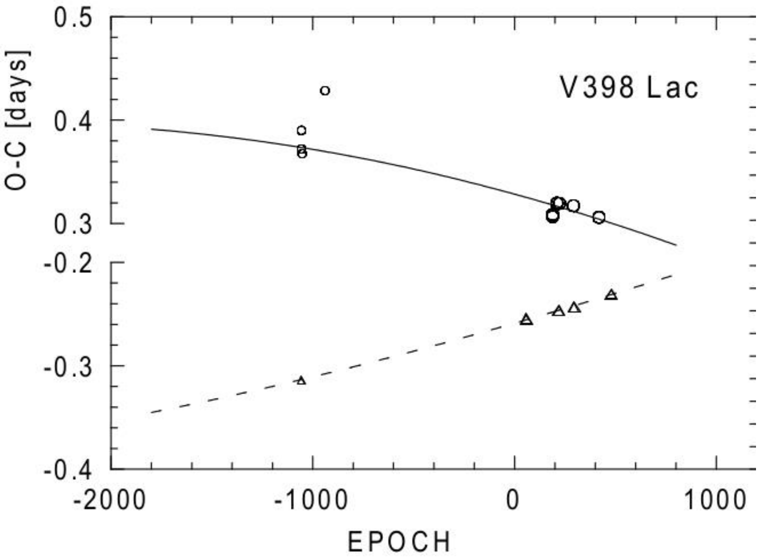

Figure 4: O-C diagram for V398 Lac.

V871 Per (*GSC 3708 1325, R.A.= 02^{h}44^{m}15^s.90 DEC.= +56°40'55".85 Equinox: 2000.0*)

(type EA, period 3.02 day, eccentricity 0.24, amplitude 10.92 – 11.5 mag)

This eccentric eclipsing binary was discovered by S. Otero (in the NSVS database). Apsidal motion period *U* = 71 years.

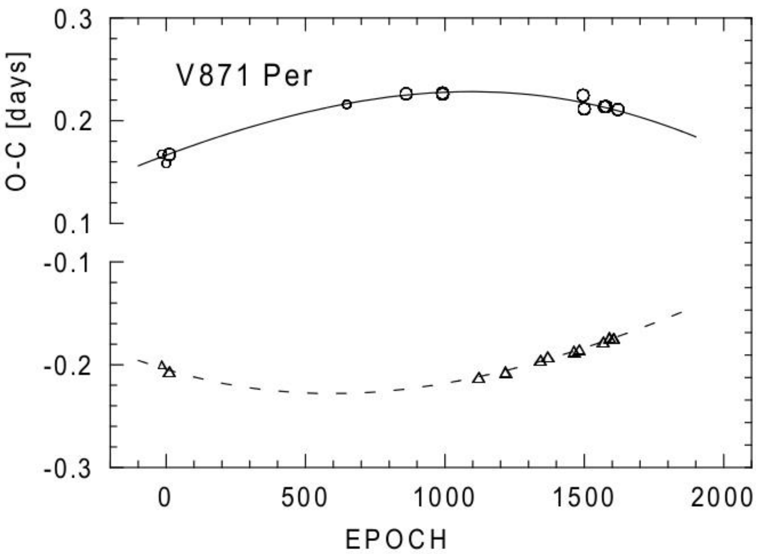

Figure 5: O-C diagram for V871 Per.

References

Wolf M. et al., 2013, A&A, 549, A108

OPEN EUROPEAN JOURNAL ON VARIABLE STARS
November 2012 http://var.astro.cz/oejv ISSN 1801-5964

MUNI FITS Photometric Archive

M. CHRASTINA, M. ZEJDA [1], M. KUBA [2]

(1) Department of Theoretical Physics and Astrophysics, Faculty of Science, Masaryk University, Brno, Czech Republic
(2) Center CERIT Scientific Cloud, Institute of Computer Science, Masaryk University, Brno, Czech Republic

Abstract: There is a number of active observers in the Czech Republic, mostly interested in photometry of variable stars and exoplanets. We can estimate they obtained 10 TB raw CCD images during last 15 years. Unfortunately, there is no central archive, in which the frames would be stored and from which could be downloaded. We work on establishing central archive of raw photometric CCD images so-called MUNI FITS Photometric Archive. In this paper some ideas, technical features and benefits to science are mentioned.

Abstrakt: Česká republika se může pyšnit velkým počtem aktivních pozorovatelů, z nichž většina se věnuje fotometrii proměnných hvězd a exoplanet. Můžeme odhadnout, že za posledních 15 let společně získali kolem 10 TB CCD snímků. Bohužel neexistuje žádný centrální archiv, do kterého by se mohly snímky ukládat a z kterého by se daly stahovat. Pracujeme na vytvoření archívu MUNI FITS Photometric Archive, jenž by tuto situaci změnil. V článku zmiňujeme několik myšlenek, technických vlastností a vědecký přínos.

CCD camera is currently the most dominant type of detector in astronomy. Almost all astronomical measurements in the Czech Republic are obtained by CCD at least for last 15 years. Reason for this is a simple physical property of CCD, which are very suitable for astrophysical measurements and low-cost and convenient operation of CCD is very important as well. The second feature is responsible for the wide-spread availability of CCDs to amateur astronomers. There are number of active observers in the Czech Republic. They are focused mainly on photometry of variable stars and exoplanets and observations are obtained on universities, scientific institutes, public and private observatories. Professional astronomers together with amateurs obtain enormous number of CCD frames. Unfortunately, there is no central archive, in which frames can be stored and from which frames can be downloaded. We can take an example at Masaryk University Observatory. There are 2.5×10^5 CCD frames (including calibrating ones) obtained during 2005-2011 taking 166 GB disk space. At average it gives 35 000 frames per year. If we take into account number of observers and observatories, their typical equipment, typical observing time usage and average period of observers' activity, we can make rough estimation that there are 10^6-10^7 frames in the Czech Republic corresponding to the data volume of order of 10 TB. If all the data would be online available, it could be very valuable source of photometric data comparable to other sources. For comparison, Sloan Digital Sky Survey Data Release 7 (SDSS 2011) contains 15.7 TB of CCD frames in FITS format. According to Annual report 2011 of Variable Star and Exoplanet Section of Czech Astronomical Society there was obtained 216 707 photometric data points into B.R.N.O project resulting this year as the most productive year at all (Brát 2012). Number of points does not contain calibrating frames and in addition the Section working on some other projects. If we take into account number of telescopes which are operated by professional astronomers, it is obvious that absolute majority of photometric measurements are obtained by amateur astronomers. This is crucial fact, which should be really considered in astrophysical research. The most photometric data is obtained by large number of amateur observers, the CCD frames are not online available and they are stored in many private archives. It is necessary to find the way how to manage the situation.

As we mentioned above, raw CCD frames are stored in many private archives. They are hardly available in the most cases by personal request only, therefore it takes a very long time to find and receive the frames. Furthermore, private archives seriously differ in file structure and data format one another. Especially, FITS headers of CCD images are very heterogeneous (Chrastina et al. 2010). Automated processing of images originated from different sources is very complicated. Processing codes have to take into account many combinations of all possibilities causing the code development takes a very long time. We believe the best way how to solve described problem is the central archive with a well-defined file structure and data format. Data in such archive will be easily accessible from one point, searching for data will be much simpler and images will contain all metadata necessary for complete data processing. Then an astronomer save his time and better use it to scientific research. Necessary conversions will be made with assistance of uploader during uploading process. Of course, due to hundreds of thousands of files it takes some uploader time requiring its great effort. However, great advantage of this approach is that, it has to be done just ones. Once the archived data have homogeneous structure and they are stored in one common place, any further task or any requested changes on stored images can be done more quickly and easily because the codes are much simple to develop.

CCD camera is two dimensional detector and therefore it may cover hundreds of stars. Typically, amateurs process images manually for each observing night. Light curve is taken just for a few stars of astronomer interest. This approach does not use all pieces of astronomical information covered by CCD image as well as it makes almost impossible to study the long-periodic variability. Furthermore, usage or comparing our data with the observational result of other colleagues requires frames/data preferably processed by the same method. There are variable stars, which are observed by several amateurs, thus collecting data and their processing using the same method means to obtain light curve better covered and to achieve higher precision as well as longer time scale can be studied. In certain sense, it is something like sky survey observations because we have some data points somehow spread in time and just for selected stars. We can illustrate this by our observations of V1710 Aql. Phased light curve fitted by phenomenological model can be seen in Figure 1. Observations were obtained at Masaryk University Observatory during 2008-2011 (other technical, data processing and fitted model parameters are not important now, it is just an example). V1710 Aql has very low declination, thus it arises very low above horizon, where observatory night sky is heavily light polluted and of course, it can be observed for only short part of year. In addition it is on telescope magnitude limit, therefore only low signal to noise ratio can be achieved even using long exposures. Finally, climate of observatory provides only cca 60 photometric nights per year. Despite all these facts, if observations are obtained for longer time with at least several points in each run, valuable data can be achieved. In case of V1710 Aql, each observing run consists of about 10 images with typical exposure 60 s. As we can see the data scatter is huge, but the statistics give us good solution, mainly due to long time scale of observations. We believe that comparable results should be achieved using our photometric archive. Processing all images using the same method as well as using the same photometry method allows a better interpretation of results. Each method has some features and it is appropriate for some data under some conditions. If one well-known method is used, that the result properties are known as well and this allows more precise physical interpretation. Central archive can provide such approach, which is another benefit to science.

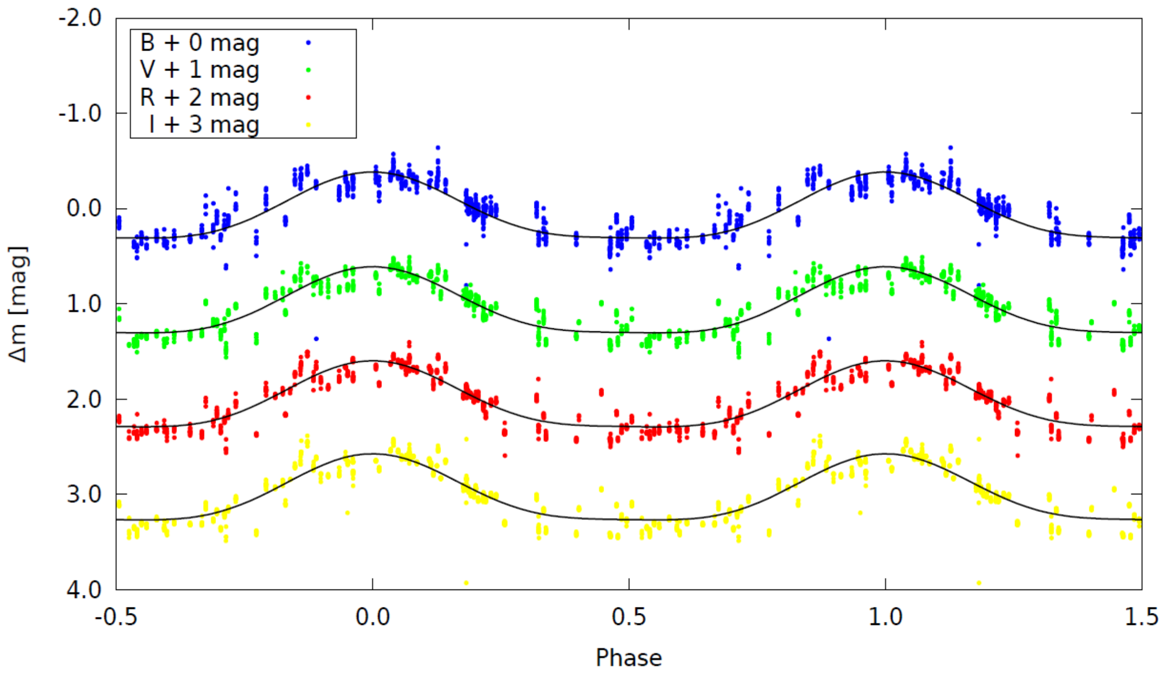

Figure 1: Phased light curve of V1710 Aql.

We work on establishing central archive of raw photometric CCD images so-called MUNI FITS Photometric Archive. It will provide photometric data in uniform format with searching possibilities and it will serve as a backup storage of private archives as well. Archive should contain data on long time scale and it will allow unified approach to data processing. First, we would like to collect CCD images from amateur astronomers. Of course, there are a lot of them, thus it takes some time during which we want to expand archive features. At the beginning, archive could serve as a backup storage of private archives. Data will be converted into unified data format during uploading process and homogeneous file structure will be used to store them. Archive will provide searching for data according metadata. In the next step we want to solve astrometry of all stars on each CCD image. If it is done, photometry for all stars could be available and crossover searching for stars could be available as well.

The implementation of the archive and its long-time operation will be provided by the Institute of Computer Science under the project CERIT Scientific Cloud (CERIT-SC), that aims to support scientific projects with information and communication technologies. CERIT-SC operates a research computing e-Infrastructure, which as of the end of the year 2012 provides the computing power of 2300 CPUs (processor cores) and data storage of 260 terabytes, with planned increase to 3500 CPUs and 3.5 petabytes of storage during the year 2013.

The MUNI FITS Photometric Archive will be developed in a series of three connected master theses of students of the Faculty of Informatics, supervised by employees of the CERIT-SC. Once developed, the archive will be operated on a professionally hosted server, i.e. with high availability, located in a protected computer room, connected to Internet backbone by 1 Gbps network link, and with regular data backups to tapes located in a geographically distant location protecting from local disasters.

The archive human interface will be web-based, featuring HTML5 file upload, thus not requiring installation of any special software except a modern web browser. The human web interface will be localized to English and Czech languages. User authentication will be based on federated identity, leveraging user accounts at already established account providers like Facebook, Google, or Czech universities involved in the eduId.cz federation.

Except the human web interface, the archive will also have a machine-oriented web API (Application Programming Interface) enabling usage of automated tools. The archive is planned to have also a Virtual Observatory interface as defined by the International Virtual Observatory Alliance (IVOA) standards.

Acknowledgements

This work has been supported by grants and projects MŠMT 7AMB12AT003, GAP 209/12/0217, and MUNI/A/0968/2009 and programme Center CERIT Scientific Cloud, part of the Operational Program Research and Development for Innovations, reg. no. CZ.1.05/3.2.00/08.0144.

References

Brát, L., 2012, http://var2.astro.cz

Chrastina, M., Zejda, M., Mikulášek, Z., 2010, In Proceedings of "Binaries - key to comprehension of the universe" held in Masaryk University (Brno, Czech Republic) on June 8-12, 2009. ASP Conference Series, 435, 83

SDSS, 2011, http://www.sdss.org/dr7

The BRITE-Constellation satellite mission

E. Paunzen [1,2]

(1) Department of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, CZ 611 37, Brno, Czech Republic, epaunzen@physics.muni.cz
(2) Rozhen National Astronomical Observatory, Institute of Astronomy of the Bulgarian Academy of Sciences, P.O. Box 136, BG-4700 Smolyan, Bulgaria

Abstract: The BRIght Target Explorer Constellation is a group of six nanosatellites from Austria, Poland and Canada equipped with 30 mm aperture optical telescopes and a CCD camera. The goal of the mission is to perform long term photometric measurements in order to detect low-level oscillations and temperature variations of the brightest stars in the sky down to a visual magnitude of 4th magnitude. The aspired goal of a 50 ppm noise level in the Fourier domain and the time coverage are not achievable from ground. With the successful launch of the two Austrian satellites on the 25th of February 2013, the project is already ongoing.

Abstrakt: Projekt *BRIght Target Explorer Constellation* je tvořen skupinou šesti nanosatelitů z Rakouska, Polska a Kanady vybavených 30mm optickým dalekohledem a CCD kamerou. Cílem projektu je provádět dlouhodobá fotometrická měření pro detekci změn jasnosti s malou amplitudou způsobených oscilacemi a teplotními změnami nejjasnějších hvězd oblohy (do 4 mag ve *V*). Z pozemských observatoří nelze dosáhnout takové přesnosti a časového rozlišení jaké je plánováno pro satelity. Projekt započal úspěšným startem rakouské dvojice satelitů 25. února 2013.

Technical overview

The BRITE-Constellation (http://www.brite-constellation.at/), which is a joint project by researchers from Austria, Canada, and Poland, will consist of six nanosatellites (Zwintz & Kaiser 2008). On the 25th of February 2013, the two Austrian ones, UniBRITE and BRITE-Austria/TUG-SAT1 were successfully launched. They are of 20x20x20 cm size (Figure 1) and have a mass of about 7 kg. Each satellite is equipped with a 30 mm aperture telescope and a Kodak CCD (KAI11002-M) with 4008x2672 pixels. The field of view is about 24° with a resolution of 26.52" per pixel. This guarantees that there are always two bright stars on the image in order to perform differential photometry.

Each pair of satellites holds either a blue (390 to 460 nm) or a red (550 to 700 nm) filter in order to perform high-precision two-color photometry which is essential for most of the astrophysical goals of the mission.

The newest technical developments in miniaturized attitude determination and control systems are implemented. Three orthogonal reaction wheels and three orthogonal vacuum-core magnetorquer coils are used for three-axis attitude control and momentum dumping. The achieved pointing accuracy is at the arc minute level.

The satellites are in a Sun-Synchrounous Polar Dawn-Dusk Low Earth Orbit (about 100 min) with a height of about 800 km. The overall power of the systems (from solar panels and one internal battery) ranges up to 10 W with a transmitting power of 0.5 W. The daily data volume of about 2 Mbyte is transmitted with a downlink rate of up to 256 kbit/s. Three ground stations in Austria, Canada and Poland guarantee a best available redundancy. The data will be already preprocessed and compressed on board before transmission.

The lifetime of the overall mission is at least two years.

Scientific Goals

BRITE-Constellation will photometrical measure, in two passbands, low-level variability, with a noise level of 50 ppm in the Fourier domain, and temperature variations in stars brighter than 4th magnitude. In addition, it will be possible to observe stars down to 7th magnitude, but with a reduced accuracy. Most of these stars are currently not investigated in respect to photometric variations.

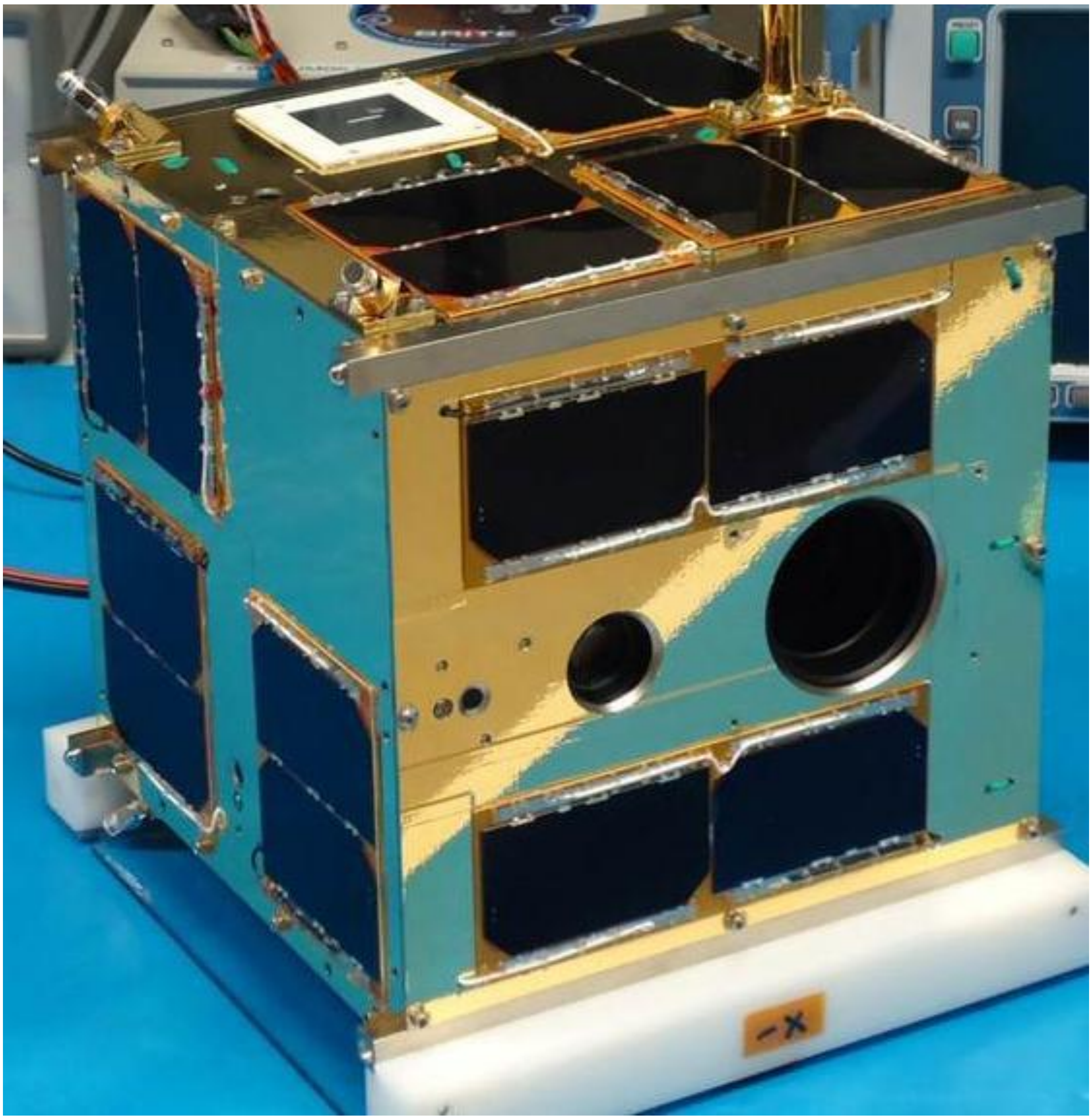

Figure 1: The BRITE satellite.

The variability of stars can be, for example, due to

- Accretion of matter,
- Binarity,
- Eruptions,
- Nova events,
- Pulsations,
- Spots,
- Stellar winds,
- Transiting planets.

All these phenomena will be studied both in the Galactic field and in stellar clusters and associations. From the classical variable star groups, the following ones will be in focus:

- O, B and Be, β Cephei stars, hot Supergiants,
- δ Scuti variables, γ Doradus pulsators,
- roAp / CP stars, red Giants , eclipsing binaries, RR Lyrae, Mira, and more.

Depending on the position of the targets the photometry can be obtained with different time basis and coverage.

If a target is in the continuous viewing zone near the poles, it can be continuously observed during many orbits for several months. However, the earth's shadow, and sun as well as moon glare during individual orbits can lead to gaps.

Nevertheless, the success of BRITE-Constellation also depends on detailed ground based preparatory work. There are two main goals for ground based complementary observations:

- to derive fundamental parameters for all target stars,
- to obtain simultaneous photometric data in other wavelengths regions and /or spectroscopy while BRITE satellites are observing particular target stars.

Only the synergy of space observations and ground-based complementary data will give scientists the best chance to understand the physics and evolutionary status of stars.

If you want to contribute ground based observations, please contact Konstanze Zwintz (konstanze@ster.kuleuven.be) for further information.

Acknowledgement: This work was supported by the following grants: GA ČR P209/12/0217, 7AMB12AT003, WTZ CZ-10/2012 and FWF P22691-N16.

References

Zwintz, K. & Kaiser, A. (edts.), 2008, Proceedings of the First BRITE Workshop, Comm. Asteroseismology Vol. 152

OPEN EUROPEAN JOURNAL ON VARIABLE STARS
November 2012 http://var.astro.cz/oejv ISSN 1801-5964

Variable stars and eclipsing binaries in open clusters

M. ZEJDA[1], E. PAUNZEN[1], V. BAKIS[2]

(3) Dept. of Theoretical Physics and Astrophysics, Masaryk University, Kotlářská 2, 61137 Brno, Czech Republic, zejda@physics.muni.cz, epaunzen@physics.muni.cz

(4) Space Sciences & Technologies Dept., Akdeniz University, Campus, 07058, Antalya, Turkey, volkanbakis@akdeniz.edu.tr

Abstract: We shortly summarized our current research of variable stars and mainly eclipsing binaries in open clusters. We presented the first catalogue of variable stars in open clusters and connected statistics. The first results of project EVRENA concentrated to eclipsing binaries in young open cluster and associations are also given.

Abstrakt: Stručně shrnujeme naši práce ve výzkumu proměnných hvězd a zejména zákrytových dvojhvězd v otevřených hvězdokupách. Je prezentován první katalog proměnných hvězd v otevřených hvězdokupách a související statistiky. Jsou představeny i první výsledky projektu EVRENA zaměřeného na výzkum zákrytových dvojhvězd v mladých otevřených hvězdokupách a asociacích.

Introduction

Open clusters (hereafter OCs) are interesting and important stellar aggregates with a set of specific characteristics:

- their sizes are much smaller than distance to the Sun, what means we can assume approximately the same distance from us for all members
- their members born in the same time and taking into account the length of process of OCs formation only millions of years, which is short compared to the lifetime of the cluster, we can assume similar age of all members
- the formation from the same initial cloud nebula leads to similar initial chemical composition of members.

Thus it seems OC´s are excellent opportunity to study individual and star groups from different points of view simultaneously. Furthermore, using CCD cameras, from which one can often obtain photometry for several members at once, such studies can be performed very efficient. We are able then study members of different masses, compare their evolutionary status and test our evolutionary models.

The present situation in OCs research is well illustrated using the catalogue of open clusters - DAML02 Catalogue, Version 3.2, Dias et al. 2002a, 2012. There is a list of 2140 OC´s, however we only have additional, detailed information for about 1100 OCs. For more information see the most complete database of open cluster characteristics and measurements WEBDA (http://webda.physics.muni.cz) (Mermilliod & Paunzen, 2003). There are some individual projects to study open clusters like WIYN Open Cluster Study for 14 northern clusters (Geller & Mathieu, 2012), Southern Open Cluster Study (SOCS) for 24 southern open clusters (Kinemuchi et al., 2010) or amount of individual open cluster studies like De Marchi et al. (2010),Twarog et al. (2011), Paunzen et al. (2010) or Janík et al. (2012).

Catalogue

To help researchers in open cluster study activities, we established a catalogue of variable stars in open clusters and their surroundings for two categories of open clusters. The first group contains OCs smaller than 60 arcmin, the second one larger than 60 arcmin. We excluded very spacious (and close to us) clusters larger than 5 degrees and Hyades. Using the VSX catalogue of known and suspected variable stars, we located 8 938 variable stars in 461 smaller open clusters and 9 127 variable objects in 74 larger open clusters. For a detail description of the catalogue see Zejda et al., 2012 (http://cdsarc.u-strasbg.fr/viz-bin/Cat?J/A%2bA/548/A97). In the process of preparation of this catalogue, we have also compiled a new catalogue of proper motions of 879 OCs. We also shortly discuss the distribution of found variable stars in OCs according to their distance to the centre of OCs and their types (see Fig. 1).

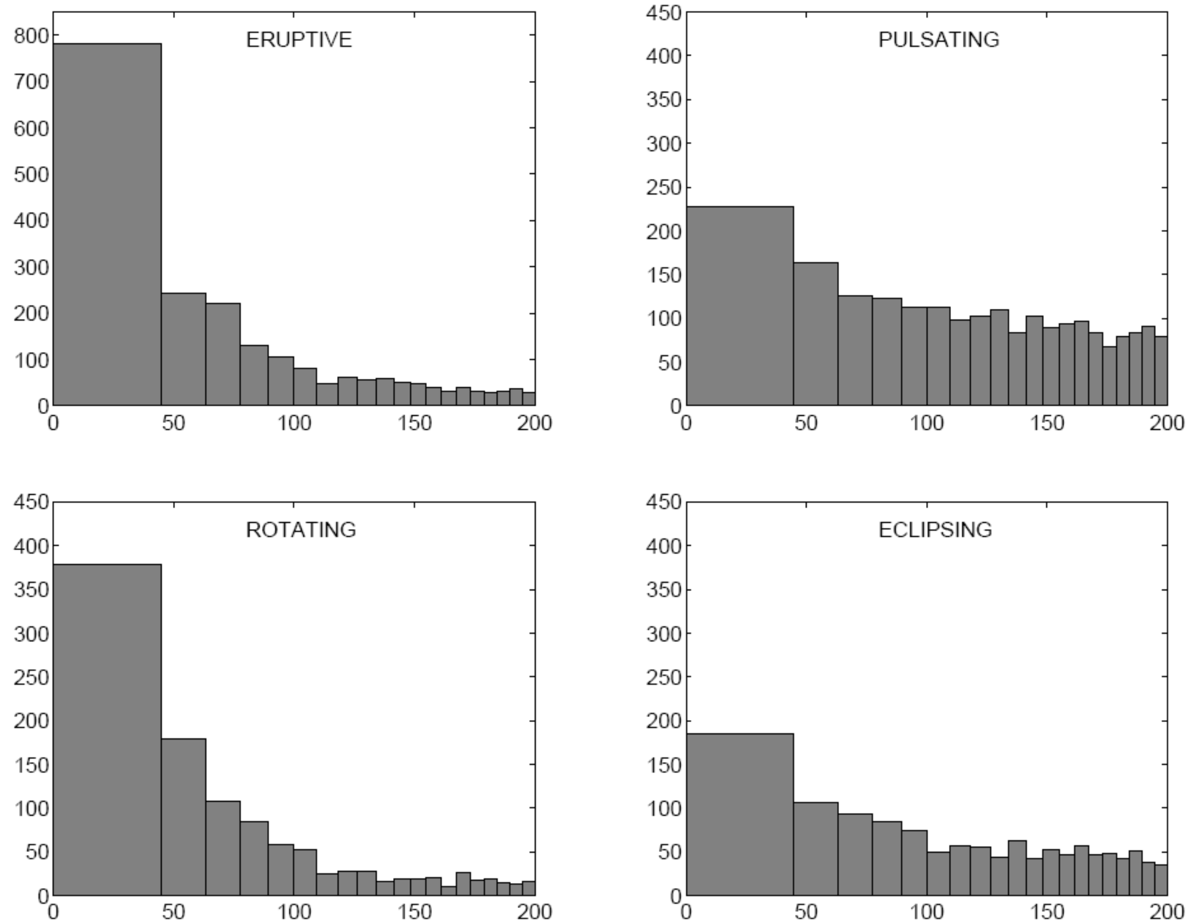

Figure 1: Distribution of the four most numerous groups of variable stars according to their distance from the center of open clusters in cluster radii in open clusters smaller than 60′ in diameter (Zejda et al., 2012).

EVRENA project

One of the very promising project devoted to young open clusters and associations is the project EVRENA. It is concentrated upon eclipsing binaries in young stellar aggregates in order to study their characteristic eclipsing binaries themselves as well as their host clusters. For such a detailed study, it is necessary to collect large amount of data for each star and analyse them using advanced methods of data processing. As an example see the study of the bright but neglected eclipsing binary IM Mon (Bakis et al., 2011). We have collected as much data as possible. However the photometric measurements were too noisy. Thus before the "traditional" astrophysical modelling of the system, we used phenomenological modelling and determined a new value of period and its possible changes. For details see (Bakis et al., 2011). The phenomenological fit is shown in Fig. 2. Then, it was possible to continue in a standard way of the study of this system but with the detail knowledge about the period and its development during last decades. Finally, we are able to conclude that the eclipsing pair belongs to association Ori OB1a and we significantly improves our knowledge about this association – distance of IM Mon 359 (7) pc, age 11.5(1.5) My and chemical abundance 0.20(0.05) dex.

The majority of stars included in the EVRENA projects are quite bright, well observable by the typically small telescopes of amateur variable star observers. Such photometric or even spectroscopic observations will be very appreciated. Those who are interested, please, contact the authors of this paper.

Acknoledgement

Part of this work was supported by the Czech grants GAP209/12/0217, 7AMB12AT003, WTZ CZ 10/2012, Austrian Research Fund via the project FWF P22691-N16, the Scientific & Technological Research Council of Turkey (TUBITAK) with the project 109T449. We appreciate the using of VSX Index of AAVSO. This research has made use of NASA's Astrophysics Data System and the WEBDA database, operated at the Department of Theoretical Physics and Astrophysics of the Masaryk University.

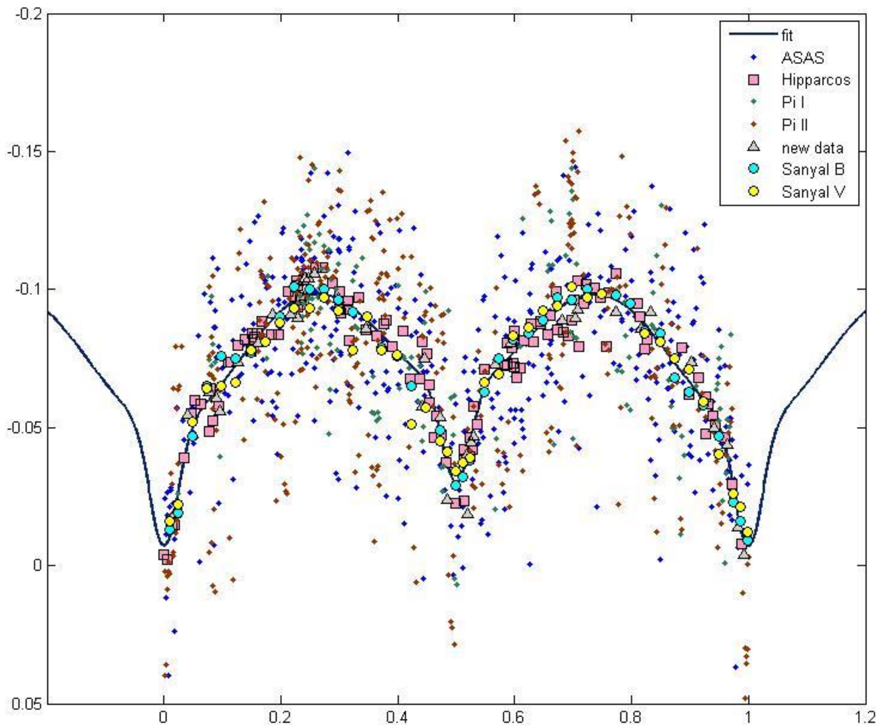

Figure 2: The light curve of IM Mon.

References

Bakis, H., Bakis, V., Bilir, S., et al., 2011, PASJ, 63, 1079

Dias, W. S., Alessi, B. S., Moitinho, A., & Lépine, J. R. D. 2002, A&A, 389, 871

Dias W. S. et al. 2012, http://www.astro.iag.usp.br/~wilton/

De Marchi, F. 2010, A&A 509, 17

Janík, J., Parimucha, Š, Paunzen, E., et al. 2012, OEJV, No. 148

Geller, A. M., & Mathieu, R. D. 2012, AJ, 144, 54

Kinemuchi, K., Sarajedini, A., Geisler, D., Mauro, F., Carraro, G., Kafka, S., & Jeffery, E. 2010, IAUS, 266, 429

Mermilliod, J.-C., & Paunzen, E. 2003, A&A, 410, 511

Paunzen, E. Heiter, U., Netopil, M., & Soubiran, C. 2010, A&A, 517, 32

Twarog, B. A., Carraro, G., Anthony-Twarog, B. J. 2011, ApJ, 727, 7

Watson, C., Henden, A.~A., & Price, A. 2012, VizieR Online Data Catalog, 1, 2027

Zejda M., Paunzen E., Baumann B., et al., 2012, A&A 548, A97

OPEN EUROPEAN JOURNAL ON VARIABLE STARS
November 2012 http://var.astro.cz/oejv ISSN 1801-5964

Variable stars observed with the STEREO satellites

M. NETOPIL [1], E. PAUNZEN [2], K. T. WRAIGHT [3], L. FOSSATI [4]

(1) Institut für Astrophysik, Universität Wien, Vienna, Austria, martin.netopil@univie.ac.at
(2) Department of Theoretical Physics and Astrophysics, Masaryk University, Brno, Czech Republic
(3) Department of Physical Sciences, Open University, Walton Hall, Milton Keynes MK7 6AA, UK
(4) Argelander Institut für Astronomie, Bonn, Germany

Abstract: Although dedicated to a completely different scientific aim, instruments on board of the Solar Observatory STEREO turned out to be extremely useful also for variable star research. We present some results for chemically peculiar stars, for which either their rotational period, or their variability due to e.g. pulsation was investigated.

Abstrakt: Přestože jsou přístroje na palubě sluneční observatoře STEREO primárně určeny pro jiné úkoly, je možné je velmi dobře využít i pro výzkum proměnných hvězd. V článku prezentujeme výsledky pro vybrané chemicky pekuliární hvězdy, u nichž jsme studovali rotační periody a jejich proměnnost způsobenou například pulsacemi.

The Solar TErrestrial RElations Observatory (STEREO) mission, consisting of two almost identical satellites (Ahead, in an Earth-leading orbit and Behind, in an Earth-trailing orbit) was launched in October 2006. This NASA mission aims to study e.g. the solar corona in three dimenions and image coronal mass ejections along the Sun-Earth line. Since one of the numerous instruments on board, the Heliospheric Imager (HI-1 A/B), turned out to be rather stable it can be also used for stellar variability studies. With a field of view of 20x20°, which are centred 14° away from the limb of the Sun, over the course of an orbit almost 900000 stars brighter than about 12^{th} magnitude are imaged within 10° of the ecliptic plane. The analysed HI-1 data have a cadence of about 40 minutes, cover so far in total four and a half years, where each of the two spacecrafts observes the stars for about 20 days with gaps of about one year. This time resolution makes the data ideal to study several types of variable stars.

However, one of the limitations originates from the image resolution of 70´´, which results in blending in more crowded areas. In such cases it is often difficult to identify the actual source of possible variability. It was also noticed that the photometric data of one satellite (A) are of considerable better quality than the ones of the twin, which shows some systematic effects. Nevertheless, with the huge amount of often unique data, STEREO is a valuable contributor for variable star research.

In a first investigation, Wraight et al. (2011) have detected 263 eclipsing binaries, about half of them new ones. One of the next attempts was the study of chemically peculiar (CP) stars, which cover the spectral type range from B to F. Some CP subgroups (about 10 per cent of upper main-sequence stars) exhibit strong overabundances for heavy elements like Si, Sr, Cr, or Eu, together with magnetic fields of up to 40 kGauss. They show rotationally induced variability due to stable spots on their surface (e.g. owing to Si enhancement) and are known as slow rotators (4 to 5 times slower than normal stars of the same spectral type). The loss of angular momentum occurs most probably already during the pre-main sequence phase due to the strong magnetic field (e.g. Stepien 2000). Therefore, they are ideally suited for the STEREO data in respect of cadence and time coverage.

About 340 of such objects compiled from the CP catalogue by Renson & Manfroid (2009) were observed with the STEREO satellites. In total, we were able to derive reliable rotational periods for 82 magnetic CP stars, more than a half of them the first measurement so far. The remaining objects turned out to be probably constant, but for most of these the presence of the before mentioned blending or a low signal-to-noise ratio prevented us to detect any reliable variability. In Figure 1 some phase folded lightcurves are presented, showing the wide variety of amplitudes and lightcurve shapes with one or two spots on the surface. The increase of secured rotational periods will help to investigate possible relations with other parameters (like mass, magnetic field strength etc.) in more detail, but also allow a better timing of e.g. polarimetric follow-up observations, since the magnetic field varies with the same period.

A recent follow-up study (Paunzen et al. 2013) deals with the variability of non-magnetic CP stars. These incorporates the cool metallic line Am stars as well as the hotter HgMn type objects. Although surface spots are already known for the latter, a rotationally induced variability is still a matter of debate. Since both groups are predominantly known as binaries, one can expect to find orbital periods for them. However, all also cover well the classical instability strip of δ Scuti, γ Doradus, and slowly pulsating B-type stars.

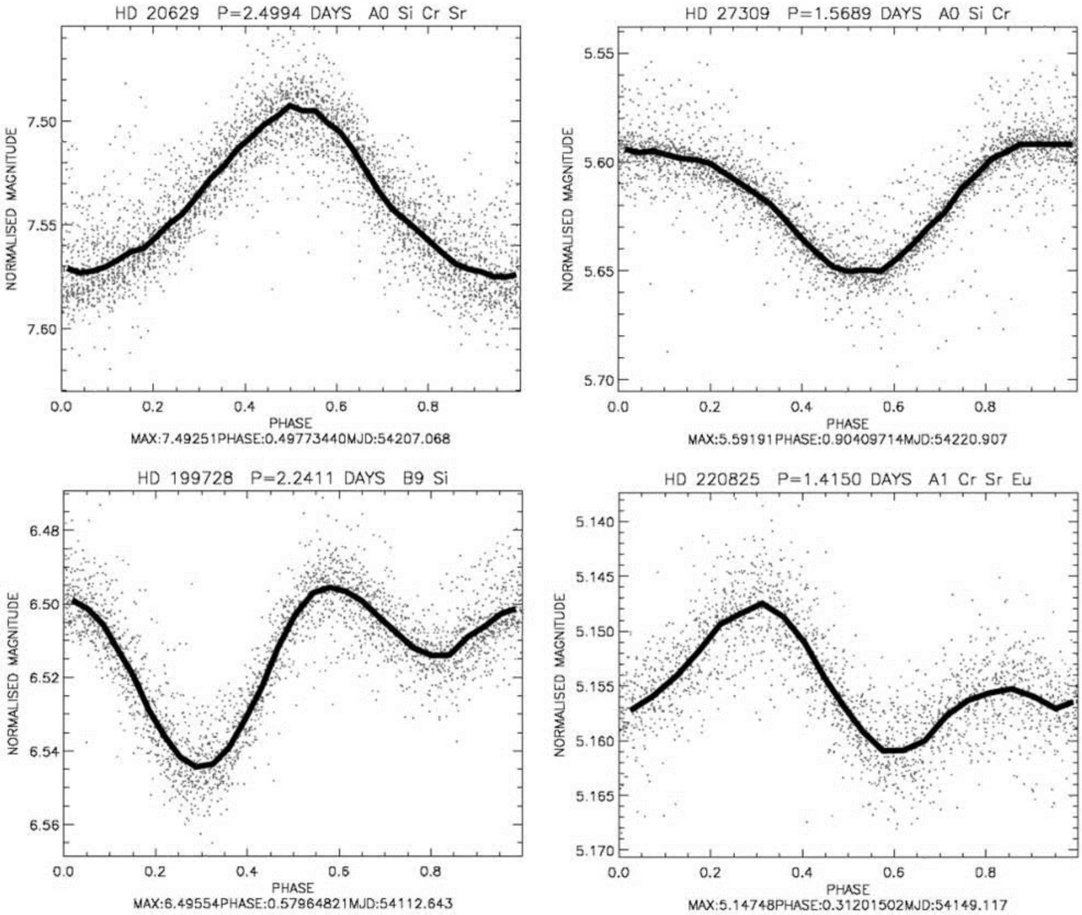

Figure 1: Some phase folded STEREO light curves of magnetic chemically peculiar stars.

From the 558 suspected non-magnetic CP stars we were able to find a photometric variability for 44 objects in the STEREO data, most of them previously unknown. According to the found frequencies, some of them were classified e.g. as hybrid pulsators, with δ Scuti and γ Dor type pulsation (e.g. Balona et al. 2011). Among the target objects also a triple system (HD 85040) can be found, consisting of two Am components and a more distant δ Scuti star, for which we found frequencies belonging to the pulsational object and orbital period of the inner system. Again, a large percentage of stars were found as (probably) constant due to blending, signal-to-noise, or systematic effects. However, although STEREO is dedicated to a completely different scientific aim, its data from the Heliospheric Imagers are an unique source to detect and investigate several types of variable stars.

References

Balona, L. A., Guzik, J. A., Uytterhoeven, K., et al., 2011, MNRAS, 415, 3531

Paunzen, E., Wraight, K. T., Fossati, L., et al., 2013, MNRAS, 429, 119

Renson, P., Manfroid J., 2009, A&A, 498, 961

Stepien, K., 2000, A&A, 353, 227

Wraight, K. T., White, G. J., Bewsher, D., Norton, A. J., 2011, MNRAS, 416, 2477

Wraight, K. T., Fossati, L., Netopil, M., et al., 2012, MNRAS, 420, 757