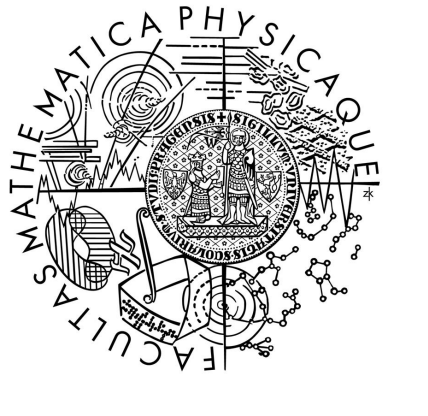
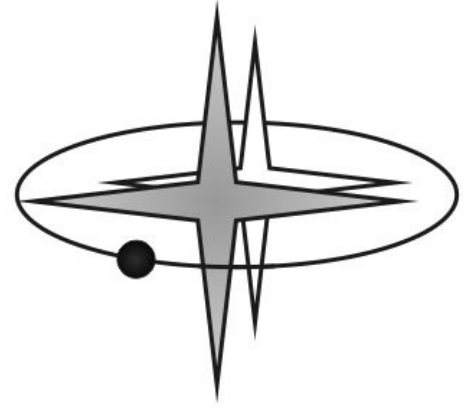


# Variable stars discovered by the Czech Astronomical Expedition 2013-2022



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## Abstract

This work presents a collection of 70 variable stars discovered by the participants of the Astronomical Expedition (see table 1), which is a yearly summer school for students aged 15 to 26 years old. It is organized in remote areas of the Czech Republic: for many years, it took place at the Úpice observatory, and recently it relocated to the village of Sítiny, Sv. Jiří. These variable stars are classified and are presented with precise periods and phased light curves.

## Methods

The objects were discovered from photometric CCD measurements made with amateur telescopes and also directly from the TESS mission. Individual TESS pixel files were inspected for possible blends, using the TESScuts python interface [1]. In some cases, data from the Zwicky Transient Facility [3] and other surveys were used to determine the periods. These newly discovered stars were published in the CzeV catalogue [4], the Czech Catalog of Variable stars.

## Results

Of the 70 newly discovered variable stars, a large portion were short period physical pulsators (40%  $\delta$  Sct stars + 7%  $\gamma$  Dor), as they are comparatively simple to discover, because of their short period and the ever-changing lightcurve. Of these, many display two or more modes of pulsations, resulting in beats, i.e. a periodic modulation of the amplitude of the pulsations. A new Cepheid star was found in Lacerta (CzeV 4339 = HD 235839, fig. 1).

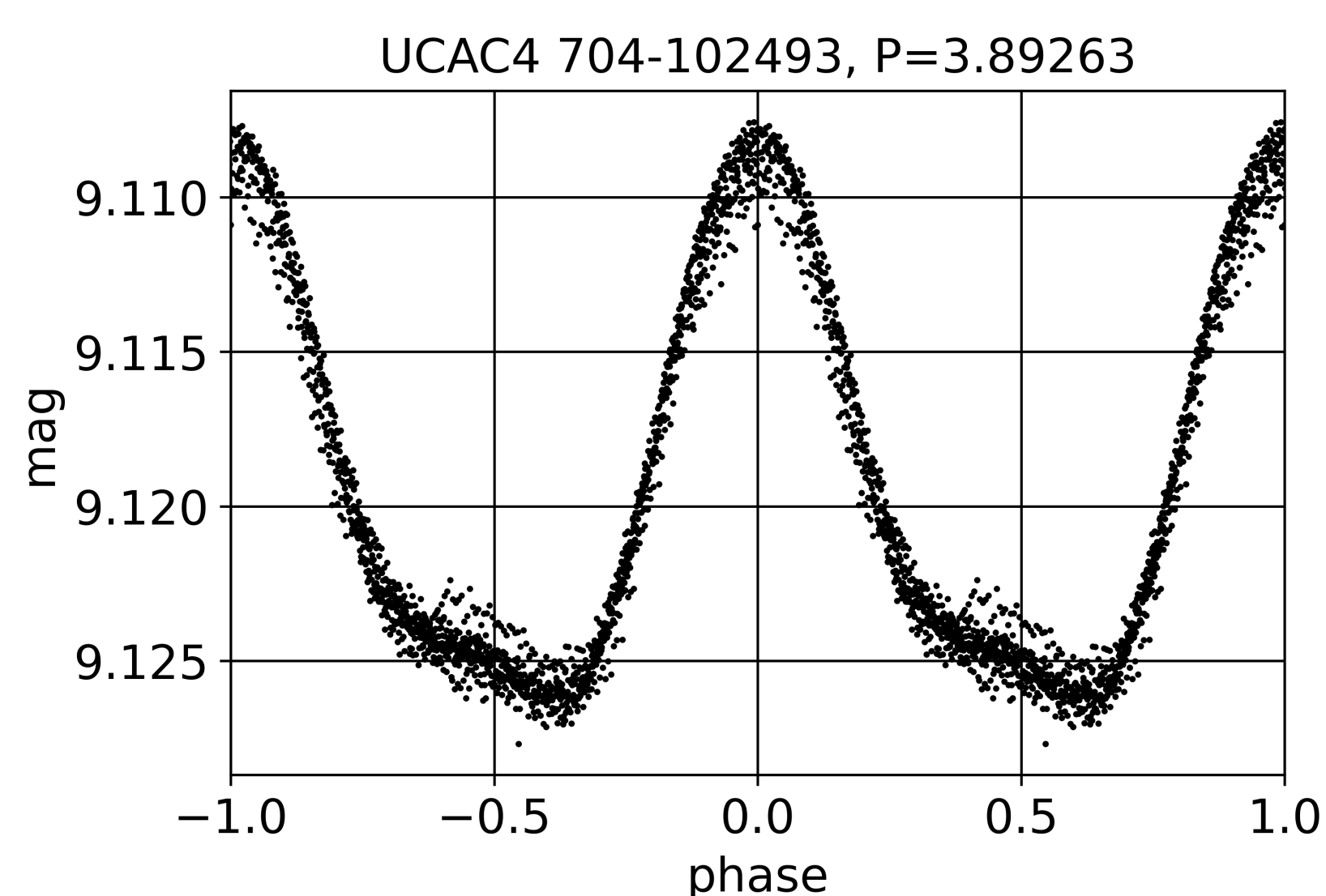


Figure 1: Phased lightcurve of the cepheid variable CzeV 4339.

A second large portion of the discoveries is composed of eclipsing binary stars, mainly close contact W UMa variables (EW, 17% of the total), Algol-type variables (EA, 16%) and  $\beta$  Lyr (EB, 7%).

Table 1: Contributors with multiple discovered stars. Some were discovered in collaboration, making the sum seemingly too large.

Discoverer	no. of stars
Tomáš Rektořík	23
Marco Souza de Joode	21
Vojtěch Dienstbier	12
Martin Mašek	5
Jakub Hadač + Vojtěch Tlustý	4
Jakub Juryšek	4
Kateřina Hoňková	4
Martin Tylšar	3
Petr Mrňák	3
Stanislav Jíra + Jiří Vala	2

Of these eclipsing binaries, several were found to have long periods (e.g. CzeV 4329 with  $P = 12.45$  days, CzeV 4331 with  $P = 8.25$  days, CzeV 4321 = HD 332681 with  $P = 7.64$  days). A representation of the discovered stars can be seen on fig. 2.

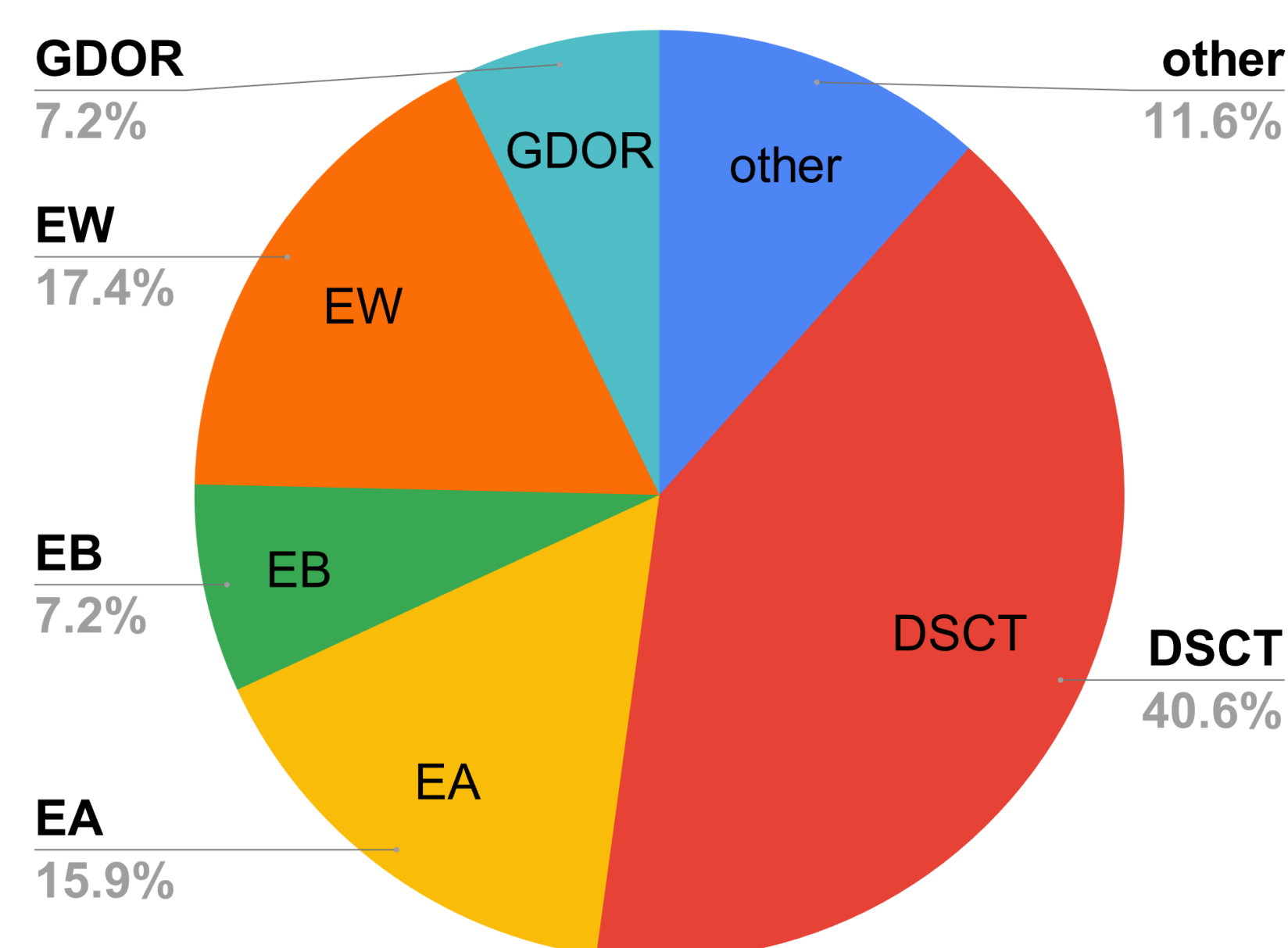


Figure 2: Variability type as a proportion of the newly discovered stars.

Some eclipsing binaries were found to be on eccentric orbits, with secondary minima occurring at a phase  $\phi_S \neq 0.5$ , e.g. CzeV 4331 with  $\phi_S = 0.59$ , CzeV 4321 with  $\phi_S = 0.48$ , corresponding to a time difference of 3.7 hours between the observed and expected secondary minima, and CzeV 4324 with  $\phi_S = 0.51$ .

In some of the binaries, a strong reflection effect was observed (e.g. the peculiar O-type star CzeV 4328, CzeV 4320), with CzeV 4352 displaying a positive O'Connell effect.

## Central star of vdB 152

The star CzeV 4335 = UCAC4 802-032402 = BD+69 1231 = TYC 4467-434-1 located at  $\alpha = 19^{\text{h}}43^{\text{m}}28.127^{\text{s}}$ ,  $\delta = +29^{\circ}36'10.47''$  is a B9.5-type star illuminating the reflection/dark nebula van den Bergh 152. The variability was seen in the TESS sectors 17, 18, 24 and 25, with a period of  $P = 0.9393$  days with an amplitude of 0.6 millimagnitudes, and was discovered in an variability search of the image 3. It has been identified as an rotating ellipsoidal variable (ELL), based on the lightcurve (fig. 4).



Figure 3: Cederblad 201 = van den Bergh 152, illuminated by the star CzeV 4335. Image by T. Rektořík

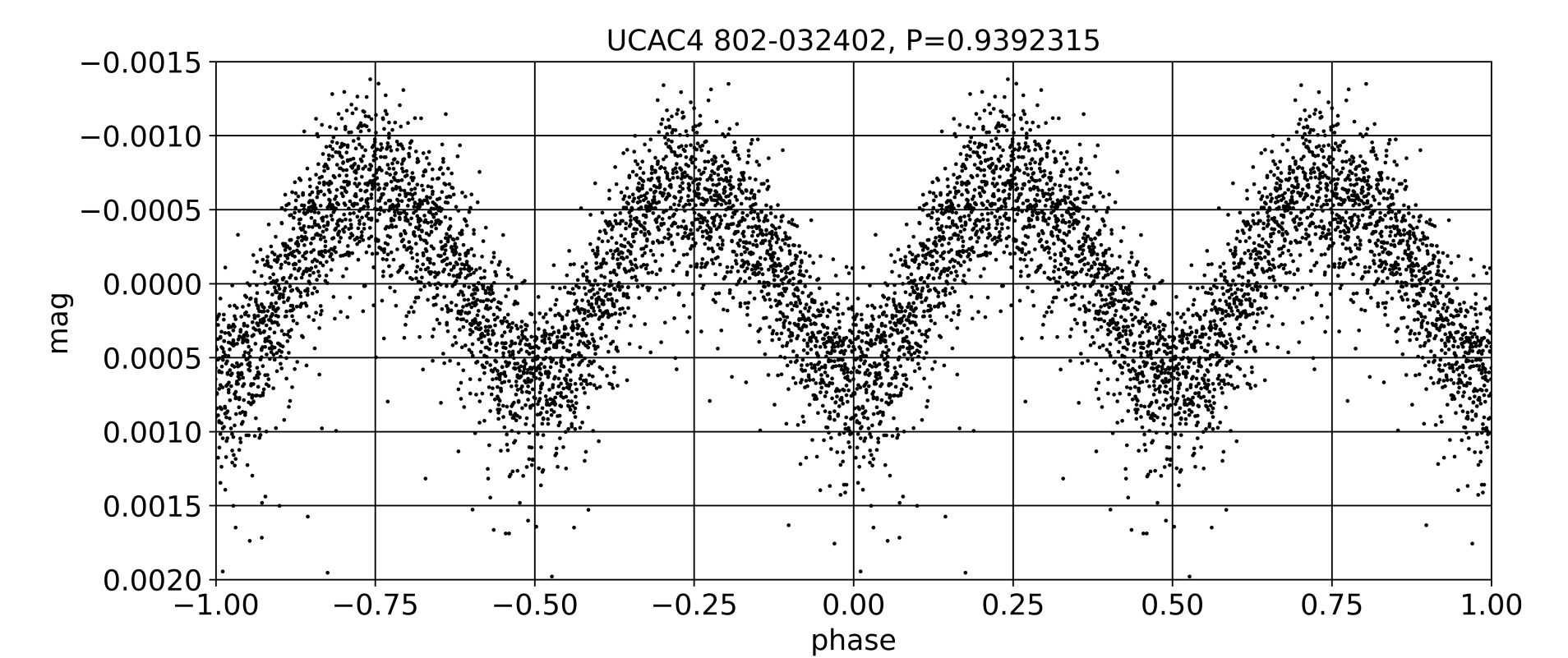


Figure 4: Light curve of the star CzeV 4335.

## A new triple system

The multiple star system UCAC4 704-102853 = BD+49 3855 was split by the means of optical speckle interferometry by [2] into two bright components with a separation of  $1.9''$ . One of the components, CzeV 4340, here presented, is an highly eccentric ( $\phi_S = 0.57$ )  $\beta$  Lyr variable strongly displaying a positive O'Connell effect.

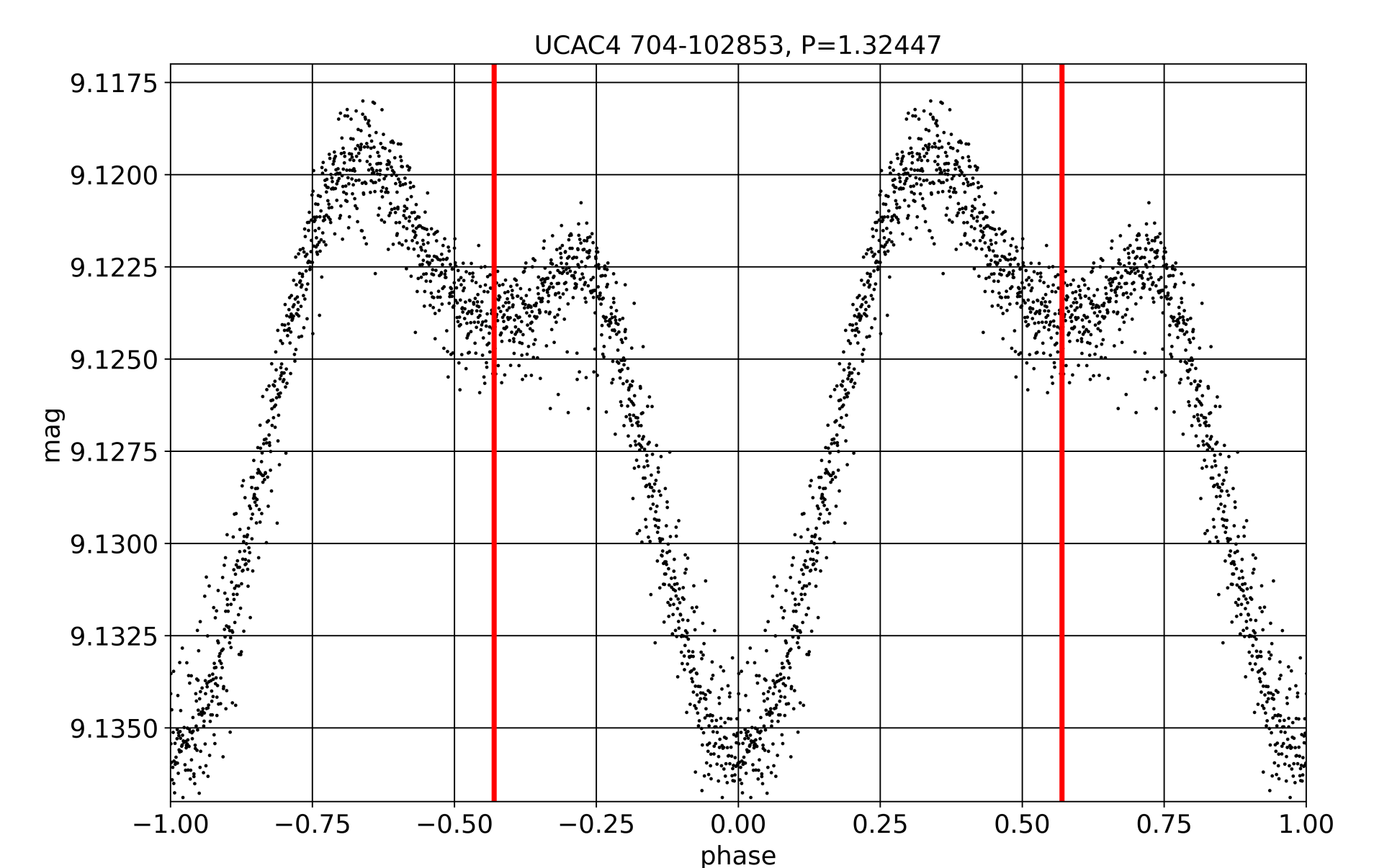


Figure 5: CzeV 4340, a  $\beta$  Lyr component of a multiple system.

## Summary and conclusions

These newly discovered systems can be further analyzed, as the study of eccentric binary stars and multiple star systems is firmly established in the Czech astronomical community. Eccentric binaries are useful tools for the study of post-Keplerian parameters, and can be used to test general relativity. A successful search for variable stars illuminating reflection nebulae is currently under way by the authors.

## Acknowledgments

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## References

- Brasseur, C. et al. 2019, Astrophysics Source Code Library, record ascl:1905.007
- Manson, B. et al. 2002, AAS, 124, 4
- Masci, F.J. et al. 2018, PASP, 131, 995
- Skarka, M., Mašek, M., Brát, L. et al. 2017, OEJV, 430, 185