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Discovery of Four β Cephei Stars in Eclipsing Systems

Andrzej Pigulski[1] and Grzegorz Pojmański[2]

[1]Instytut Astronomiczny Uniwersytetu Wrocławskiego, Kopernika 11, 51-622 Wrocław, Poland
email: pigulski@astro.uni.wroc.pl

[2]Obserwatorium Astronomiczne Uniwersytetu Warszawskiego,
Al. Ujazdowskie 4, 00-478 Warszawa, Poland
email: gp@astrouw.edu.pl

Abstract. Using the ASAS-3 photometry, we find the components of four eclipsing binary systems — V916 Cen, HD 101838, V4386 Sgr and HD 168050 — to be β Cephei-type pulsators. The first two systems are members of the young open cluster Stock 14. The pulsating stars are presumably the primary, more massive components in all these systems. The components are detached and for at least two systems, V916 Cen and HD 168050, we may suspect that they will appear to be double-lined spectroscopic ones. In consequence, these stars become very attractive targets for studying pulsations in β Cephei stars by means of asteroseismology.

Keywords. eclipsing stars, pulsating stars

1. Introduction

There is a growing interest in studying stellar interiors of pulsating stars by means of asteroseismology. A general requirement for the method is the detection of several modes which are correctly identified in terms of the geometry of the pulsation and accurate stellar parameters needed in modeling. In this context, the fact that a pulsating star is a component of an eclipsing binary is a great asset because it provides a direct way of obtaining masses and radii of the components through a combination of the double-lined spectroscopic orbit and the analysis of the light curve.

Most types of pulsating stars are known to occur in binaries, but still such cases are rare. Among over a hundred presently known β Cephei-type stars, there are only three that are components of the eclipsing systems. These are 16 (EN) Lac (Jerzykiewicz *et al.* 1978, Pigulski & Jerzykiewicz 1988), V381 Car in NGC 3293 (Engelbrecht & Balona 1986, Jerzykiewicz & Sterken 1992, Freyhammer *et al.* 2002) and λ Sco (Shobbrook & Lomb, De Mey *et al.* 1997, Uytterhoeven *et al.* 2004, Bruntt & Buzasi 2006).

2. The data

The data we used consist of the V-filter photometry obtained in the third phase of the All Sky Automated Survey (ASAS-3) (Pojmański 1997, 2001, Pojmański *et al.* 2005). They span the interval of over five years, 2000–2006.

3. The systems with pulsating components

The general data for the four eclipsing systems under consideration are summarised in Table 1. Their orbital periods range from about 1.463 d for HD 101794 up to 10.798 d for HD 167003. Accidentally, two of the four stars, V916 Cen and HD 101838, are members of

Table 1. Data for the four new β Cephei stars in eclipsing systems.

HD	ASAS name	V [mag]	$P_{\rm orb}$ [d]	Short period(s) [d]	Remarks
101794	114225−6228.6	8.68	1.46324	0.22465, 0.54362	V916 Cen, Be star member of Stock 14
101838	114249−6233.9	8.42	5.41166	0.31973	member of Stock 14
167003	181442−3308.5	8.45	10.79824	0.14765, 0.13252 0.14253, 0.18593	V4386 Sgr
168050	181839−1906.2	9.81	5.02335	0.1802(var), 0.19044	

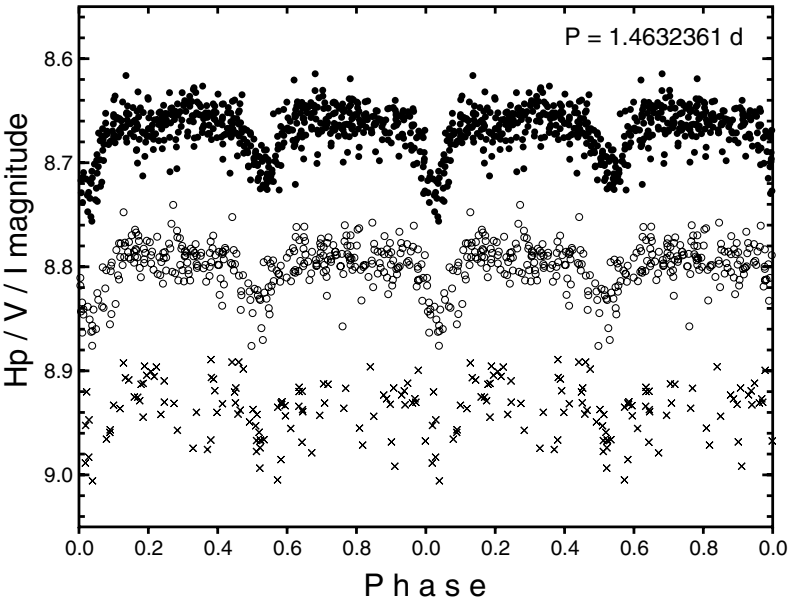

Figure 1. The ASAS-3 eclipsing light curve of V916 Cen folded with the orbital period of 1.4632361 d. The filled circles, open circles and crosses stand for the ASAS-2, ASAS-3 and Hipparcos data, respectively.

the same open cluster, Stock 14 (Moffat & Vogt 1975, FitzGerald & Miller 1983, Peterson & FitzGerald 1988). In addition, HD 101794 is known as a Be star (Garrison *et al.* 1977). In this star, one of the small-amplitude periodic variations has a period of 0.54362 d. This is slightly too long for a β Cephei star, but can be attributed either to a g mode or λ Eri-type of variability.

As far as the number of detected modes are concerned, only HD 101838 was found to be monoperiodic. The largest number of modes – four – was detected in HD 167003. In HD 168050 we detect two modes. One of them shows very fast period changes. HD 168050 is therefore one of the very few β Cephei stars which are known to exhibit secular period changes. Since the period of the other mode is constant within errors, the most plausible explanation for the observed period change is some kind of resonant coupling between modes.

From the point of view of the future application of asteroseismology, all four stars are very attractive targets. The deepest secondary eclipses are observed in HD 101794 and HD 168050, which indicates that these systems will be observed as a double-lined

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spectroscopic ones. This could allow precise determination of masses and radii of the components. They are therefore obvious targets of the follow-up study.

As an example, we show in Figure 1 the eclipsing light curve of HD 101794. The star was found to show erratic changes of γ Cas-type by Hipparcos, but the eclipses in this system were discovered by Pojmański (2000) in the ASAS-2 I-filter data. We show the light freed from the contribution of pulsations and long-term changes. They originate probably in a Be star.

The full study of the four systems will be published elsewhere.

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