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THE OBSERVATIONS OF TWO UNUSUAL ECLIPSING BINARIES, FN CAM AND AG VIR

E. A. Avvakumova[1], O. Yu. Malkov[2], A. A. Popov[1] and A. Yu. Kniazev[3,4]

[1] *Kourovka Astronomical Observatory, Institute of Natural Science, B.N. Yeltsin Ural Federal University, 19 Mira St., Yekaterinburg 620000, Russia; Ekaterina.Avvakumova@urfu.ru*

[2] *Institute of Astronomy of the Russian Acad. Sci., 48 Pyatnitskaya St., Moscow 119017, Russia; malkov@inasan.ru*

[3] *South African Astronomical Observatory, PO Box 9, Observatory 7935, South Africa; akniazev@saao.ac.za*

[4] *Sternberg Astronomical Institute, Moscow State University, 13 Universitetskij Prosp., Moscow 119992, Russia*

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Abstract. Based on results of classification of eclipsing binaries we have compiled a list of stars that are promising objects for future study. We have started the observational campaign with the telescopes of Kourovka Astronomical Observatory, Russia and in this work the first results are presented.

Key words: Stars: binaries: eclipsing — stars: individual — techniques: photometric

1. INTRODUCTION

Binary stars are numerous and provide the methods by which fundamental stellar parameters (such as mass, radius, luminosity, etc.) can be independently estimated. It is true for cases when we observe binary star as eclipsing and SB2 (when lines of both components are seen in the composite spectra) simultaneously. The precision of the derived values will be as high as several percentages.

However the number of such systems is only about 2% of full amount of known binaries and will not increase considerably in the future.

On the other hand there are a huge amount of eclipsing binaries discovered during ground-based and space surveys, which still remain unstudied. We can use the limited amount of available information on new binaries for the determination of their evolutionary stage and for searching the unusual systems which belong to the rare evolution stages. For these purposes we have developed the method for the assessment of evolutionary status of eclipsing binaries using light-curve parameters and spectral classification (Avvakumova & Malkov 2014). We have applied the procedure for the list of eclipsing binaries, which were collected in the

catalogue of eclipsing variables (CEV[1], Avvakumova et al. 2013). About 4000 of binaries were classified successfully but also we have found that some systems can not be classified at all or multi-valued classification is possible. To find out the reason we have checked all these binaries with the literature and stated the three problems:

1. obsolete or unconfirmed values of observational parameters can obstruct the classification;
2. contradictory values of parameters can lead to uncertain classification;
3. extreme and unusual systems sometimes can not be classified.

The last item is the source of the promising binaries with unusual evolutionary state, which can be very useful for stellar evolution theories, while the first and the second ones are both can be solved with the new observations and/or investigation.

Full lists of unclassified binaries were published with the CEV on the CDS. Based on data about binaries which satisfy first and second items above we have compiled list of twelve objects which we can observe photometrically and spectroscopically with the telescopes of the Kourovka Astronomical Observatory, Russia. These binaries are enumerated in table 1. Observational campaign has started in January, 2014.

In this work we present preliminary results of observations of two eclipsing binaries, FN Cam and AG Vir, for which we have found contradictory data on evolutionary state. In section 1 we give the short description of known properties of both binaries. In the next section we describe our observations and their reduction for each system. In section 3 we draw our conclusions.

2. PROPERTIES OF STUDIED SYSTEMS

2.1. FN Cam

FN Cam (α=09$^{\rm h}$22$^{\rm m}$58.$^{\rm s}$04, δ=+77°13′10.9″, V_{max} = 8$^{\rm m}$.64) is the SB2 eclipsing binary which was discovered by Hipparcos (Perryman 1997). Rucinski et al.(2001) published first radial velocities and classified system as A-subclass of W UMa systems what agrees with the results of the solution of light curves (Pribulla et al. 2002b). Pribulla et al.(2002a) stressed that system is quite overmassive for its spectral classification.

Csizmadia & Klagyivik(2004) added FN Cam to their catalogue and, opposite to the conclusions of Rucinski et al.(2001), classified it as W-subclass of W UMa binaries. Selam (2004) derived new solution of light curves of Pribulla et al.(2002a) via the Fourier fitting. His results differ slightly from the ones of Pribulla et al.(2002a).

Therefore both A and W-type are possible for the FN Cam and the question is still open. As this binary is SB2, masses and radii of its components can be determined with a good precision. We have decided to observe it spectroscopically with the high resolution spectrograph UFES of the Kourovka observatory. These observations give the opportunity to derive new radial velocities and estimate spectral types for both components. Simultaneous analysis of radial velocity curves and new photometric light curves lead to the determination of physical parameters.

[1]online live-version can be downloaded from http://www.inasan.ru/∼malkov/CEV/

Table 1. List of programme binaries

Name	V_{max}, mag	Coord	Time of obser.	Technique
FN Cam	8.64	$09^h22^m58.^s04$; $+77°13'10.9''$	Jan–March	CCD[1] (V,R); HR[2]
AG Vir	8.78	$12^h01^m03.^s50$; $+13°00'30.0''$	Feb–April	CCD (V,R); HR
ϵ Umi	4.22	$16^h45^m58.^s24$; $+82°02'14.1''$	May–June	HR
TZ Dra	9.32	$18^h22^m11.^s67$; $+47°34'08.0''$	May–June	CCD (V,R); HR
V1034 Cyg	10.06	$20^h05^m34.^s81$; $+30°58'33.1''$	June–Sept	CCD (V,R); HR
V628 Cyg	12.20(B)	$21^h34^m03.^s96$; $+47°14'21.9''$	July–Sept	CCD (V,R)
V680 Cyg	10.35	$21^h53^m44.^s44$; $+53°48'13.06''$	July–Sept	CCD (V,R); HR
V741 Cas	8.14	$00^h10^m10.^s46$; $+64°38'48.2''$	July–Sept	CCD (V,R); HR
ZZ Cep	8.60	$22^h45^m02.^s61$; $+68°07'58.4''$	Aug–Oct	HR
GS Cep	10.41	$22^h51^m29.^s51$; $+57°00'17.9''$	Aug–Oct	CCD (V,R);
RX Ari	9.41	$02^h15^m20.^s78$; $+22°34'11.1''$	Sept–Nov	CCD (V,R); HR
AL Cas	12.30(B)	$02^h13^m44.^s65$; $+70°08'42.9''$	Sept–Nov	CCD (V,R)

[1] ccd photometry; [2] high resolution spectroscopy

2.2. AG Vir

AG Vir (α=12$^{\rm h}$01$^{\rm m}$03$^{\rm s}$.50, δ=+13°00′30.0″, V_{max} = 8$^{\rm m}$.52) is a one of the eclipsing binaries with well known and stable O'Connell effect and was the subject of numerous investigations since its discovery by Guthnick & Prager (1929). The review of observations of AG Vir until 1970 can be found in Blanco & Catalano (1970). Photometric study of AG Vir were performed by Wood (1946), Binnendijk (1969), Blanco & Catalano (1970), Niarchos (1985), Kaluzny (1986). Blanco & Catalano (1970) analyzed all previously published minima times and supposed the cyclic variation of the orbital period together with the secular increasing and classified system as semidetached with the more massive primary filling its Roche lobe.

Kaluzny (1986) derived solution of the published light curves with Wilson–Devinney code. According to his suggestions system is contact with components in poor thermal contact, and light curves asymmetry can be explained by the "hot spot" on the surface of more massive and larger primary.

Bell et al.(1990) shown that orbital period is stable and physical configuration of AG Vir depends on adopted spot model. However, Qian (2001) shown that O-C can be explained with the sum of secular increasing and cyclic variations with period close to ones of Blanco & Catalano (1970). The cyclic variation are caused by the third body, trace of which was later found by Pribulla et al.(2006). Pribulla et al.(2011) carried out photometric and spectroscopic observation, but failed to derived simultaneous solution of light curves and broadening functions (BFs). They noticed that BFs of AG Vir indicates the stream of matter or bright region.

Despite a lot of investigations there are no clear conclusions about evolutionary state of AG Vir and properties of its components. The possible configuration of 'hot area' is also still unknown. Pribulla et al. (2011) stressed that high-resolution spectroscopy near the H_α or Ca II H and K is needed for future study. Because of these reasons we have added this binary to our list.

3. OBSERVATION AND REDUCTION

Photometric observations of FN Cam and AG Vir were carried out between February and April, 2014 with the Master-II-Ural telescope at Kourovka Astronomical Observatory, Ural, Russia (Lipunov et al. 2010). During 7 nights, we obtained 2793 frames in the V and R bands with 5 sec and 10 sec exposure times for FN Cam. Because of the non optimal weather conditions we obtained only about 1000 frames in V and R bands for AG Vir.

For photometric calibration, we used dark-current frames obtained before each observational night and flat-field frames obtained on the morning twilight sky after every observational night. All observations were carried out in automatic mode.

The whole reduction process were performed for the 2414 frames of FN Cam and for the 974 frames of AG Vir in both V and R bands. The mean accuracy of our measurements is 0$^{\rm m}$.002 in both filters for both binaries.

To convert the instrumental magnitudes to the standard system we have used photometric data of APASS project (The AAVSO Photometric All-Sky Survey) for the same sky region for all non-variable stars fainter than 10$^{\rm m}$.

With the Kwee and van Woerden (1956) method we have calculated four minima times which are listed in Tab. 2. We also checked (O-C) curves of both binaries for the possible variability but did not get any clear evidence of any kind

Table 2. Minima times for FN Cam and AG Vir

FN Cam			AG Vir		
2456710.34622 (11)	II	V,R	2456769.40757 (42)	I	V,R
2456711.36155 (15)	I	V,R	2456770.37683 (41)	II	V,R

of variations.

4. CONCLUSIONS

In this work we have presented preliminary results of our observations of two eclipsing binaries FN Cam and AG Vir. We observed both stars photometrically in V and R passbands and derived almost full phase coverage for FN Cam, while for AG Vir our observations cover only part of the phased light curve.

The follow up of our work includes analysis of spectroscopic observations which were carried out for both stars as well as estimation of physical parameters for these binaries based on our photometric and spectroscopic study.

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