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NEW RESULTS ON SPECTRAL AND PHOTOMETRIC VARIABILITY OF V806 CASSIOPEIAE

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V806 Cas = HD 236071 = MWC 1076 is a star with emission lines. For the first time its spectrum was described by Merrill et al. (1948) and Burbidge & Burbidge (1954). On the slit spectrograms, obtained in 1948, H I lines were observed in emission, and lines of He I in absorption (Merrill et al., 1948). Later the object has been included in some catalogues of eclipsing variable stars (Kohoutek & Wehmeyer, 1999, Malkov et al., 2006, Avvakumova et al., 2013). The information on its brightness is quite limited: $V = 8\overset{\mathrm{m}}{.}7$ (Merrill et al., 1948), $B = 8\overset{\mathrm{m}}{.}99$; $B - V = +0\overset{\mathrm{m}}{.}25$ (Haupt & Schroll, 1974), $V_{\max} = 9\overset{\mathrm{m}}{.}0$; $V_{\min} = 9\overset{\mathrm{m}}{.}20$ (Malkov et al., 2006). Estimations of the spectral class of the object vary from B3 (Burbidge & Burbidge, 1954) up to A0pe (Malkov et al., 2006, Avvakumova et al., 2013). It was supposed by Avvakumova et al. (2013), that changes of brightness may be connected with periodic eclipses of a hot component by a red giant or a supergiant. The orbital period is unknown.

Our quasi-simultaneous photometric and spectroscopic observations of V806 Cas were carried out in 2008-2014. Photometric observations were made with two telescopes: 1-meter Carl-Zeiss Jena reflector, equipped with CCD ST-7 (765×510, 9 μm) and 70 cm telescope AZT-8, equipped with CCD ST-8 (1530×1020, 9 μm, and samples of BVR_{C} filters). Usually two series of BVR_{C} images of the studied object were obtained successively. All images were dark subtracted and flat fielded. The resulting BVR_{C} magnitudes are compiled in Table 1. Errors of measurements do not exceed $0\overset{\mathrm{m}}{.}01$. Rapid (within 5 minutes) decrease by about 0.15 mag has been registered in V filter on 26.09.2011. We consider this variation to be real, because the brightness of a control star remained constant.

It is important to note, that the brightness of the object in different filters varies practically synchronously. Colour indices change within $0\overset{\mathrm{m}}{.}16 - 0\overset{\mathrm{m}}{.}19$ for $(B - V)$ and $0\overset{\mathrm{m}}{.}27 - 0\overset{\mathrm{m}}{.}31$ for $(V - R_{\mathrm{C}})$, and they do not correlate with the brightness level. Typical light curves of eclipsing variables exhibit deep minima caused by eclipses of the binary components. During our observation similar event was not observed, because our data were probably too scanty. However a periodicity is suggested by the brightness variations. The time intervals between two observed minima and two maxima correspond to 1117 ± 10 days (Figure 1). Such variations can be connected with pulsation of the star or with a non-uniform surface brightness (spots?) on a rotating star. If V806 Cas is a double system, it is possible to expect some changes of absorption on the line of sight for different orbital positions.

Table 1: Photometric B, V, R_C observations of V806 Cas

Date	HJD	B	V	R
	2400000+	mag	mag	mag
31.11.2008	54801.097	9.22	9.05	8.81
14.10.2009	55119.210	9.29	9.08	8.84
16.10.2009	55121.169	9.38	9.17	8.88
11.08.2010	55420.304	9.24	9.06	8.74
02.09.2011	55807.300	9.40	9.11	8.83
26.09.2011	55831.267	9.39	9.23	8.95
26.09.2011	55831.271	9.41	9.38	8.94
10.10.2012	56211.090	9.38	9.20	8.92
17.11.2012	56249.101	9.24	9.08	8.82
02.09.2013	56538.331	9.16	8.98	8.72
03.10.2013	56569.228	9.28	9.09	8.83
04.11.2013	56601.156	9.27	9.06	8.81
27.08.2014	56897.295	9.48	9.21	8.82
20.09.2014	56921.249	9.39	9.14	8.84
17.10.2014	56948.234	9.45	9.18	8.91

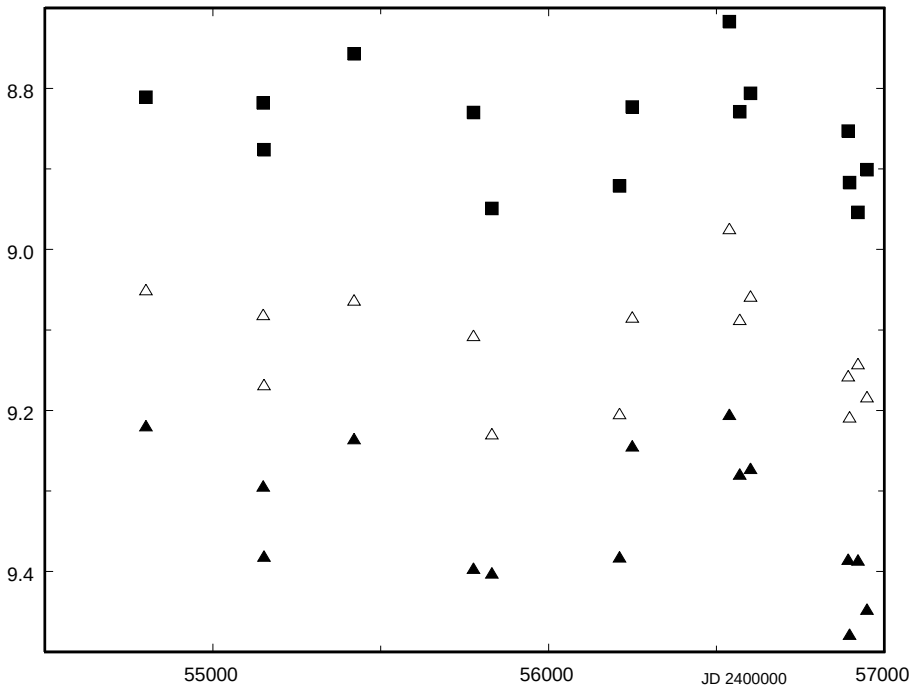

Figure 1. Light curve of V806 Cas from 2008 to 2014. BVR magnitudes are marked by full, empty triangles and squares.

Table 2: List of spectral observations

Date	HJD	Range	Telescope	$R = \lambda/\Delta\lambda$
	2400000+	Å		
28.09.2008	54738.104	4000-4800	1-meter	9000
	54738.125	4400-5200	1-meter	10000
	54738.146	6100-6900	1-meter	13000
27.11.2008	54798.090	4300-5400	AZT-8	7000
	54798.110	6000-7200	AZT-8	9000
30.11.2008	54801.082	4400-5200	1-meter	10000
	54801.103	6100-6900	1-meter	13000
14.10.2009	55119.196	6100-7300	AZT-8	9000
16.10.2009	55121.185	4400-5200	1-meter	10000
	55121.206	6100-7300	1-meter	13000
18.10.2009	55123.202	3950-5200	AZT-8	7000
12.08.2010	55421.308	4400-5200	1-meter	10000
	55421.330	6100-6900	1-meter	13000
26.09.2011	55831.235	4400-5200	1-meter	10000
	55831.256	6100-7300	1-meter	13000
10.10.2012	56211.165	4400-5200	1-meter	10000
	56211.186	6100-7300	1-meter	13000
17.11.2012	56249.077	4400-5200	1-meter	10000
02.09.2013	56538.264	4300-5400	AZT-8	7000
	56538.285	6000-72000	AZT-8	9000
03.10.2013	56569.150	4000-5200	AZT-8	7000
	56569.172	4400-5200	1-meter	10000
	56569.190	6100-6900	1-meter	13000
04.11.2013	56601.094	4400-5200	1-meter	10000
	56601.115	4400-5200	1-meter	10000
	56601.137	6100-6900	1-meter	13000
27.08.2014	56897.327	4400-5200	1-meter	10000
	56897.284	6100-6900	1-meter	13000
20.09.2014	56921.214	4400-5200	1-meter	10000
	56921.235	6100-6900	1-meter	13000
17.10.2014	56948.226	4400-5200	1-meter	10000
	56948.246	6100-6900	1-meter	13000

Spectral observations have been carried out with two spectrographs, attached to the mentioned telescopes and equipped with the CCD cameras ST-8. The slit width equals to 3 - 4″. A standard procedure of dark subtraction, flattening and wavelength calibration with a laboratory source of HeI, NeI and ArI emission lines was applied. Spectra of standard stars HD 218376 and 224572, obtained just before or after the target, were used for the flux calibration. All results were corrected for atmospheric extinction. The list of spectral observations is given in Table 2.

There were only three nights, when the spectral range of observation was extended up to 3950 - 4000 Å. Lines Hϵ, Hδ and Hγ were in absorption. Their radial velocities were measured with an accuracy $\sim$ 50-55 km/sec, which is limited by dispersion of 0.75 Å per pixel. The following heliocentric velocities have been obtained:

28.09.2008 V_r(Hγ)=−10 km/sec
18.10.2009 V_r(Hϵ)=−240 km/sec, V_r(Hδ)=−220 km/sec, V_r(Hγ)=−180 km/sec
03.10.2013 V_r(Hδ)=−180 km/sec, V_r(Hγ)=−140 km/sec.

Table 3: Characteristics of the Hβ line

HJD	Hβ profiles			Radial Velocities of Hβ components		
2400000+	$F_{\rm abs}$	EW	V/R	Emission	Absorption	Emission
	10^{-12}	Å		V		R
54738.125	0.92±0.09	0.9±0.1	0.19	−175	−85	+35
54801.082	2.02±0.15	2.1±0.1	0.26	−165	−75	+20
55152.185	1.00±0.08	0.9±0.1	0.02	−195	−110	+50
55421.308	0.47±0.16	0.4±0.1	0.24	−190	−85	+55
55831.235	0.73±0.03	0.8±0.1	0.31	−210	−120	+35
56211.165	1.10±0.09	1.1±0.1	0.58	−180	−75	+45
56249.077	0.69±0.11	0.6±0.1	0.83	−160	−85	+40
56538.254	0.90±0.11	0.9±0.1	0.36	−155	−65	+75
56569.150	1.28±0.02	1.2±0.1	<0.05	—	−100	+50
56601.094	0.75±0.10	0.9±0.1	<0.05	−155	−90	+45
56896.261	0.80±0.11	0.9±0.1	0.25	−215	−125	+30
56921.214	0.24±0.06	0.3±0.1	0.62	−210	−105	+10
56948.226	1.17±0.07	1.2±0.1	<0.1	−200	−105	+60

Emission profiles of Hβ and Hα displayed double-peaked profiles. Weak line HeI, 6678 Å was observed in absorption on all our spectrograms. The results of spectral observations are presented in Table 3 and Table 4. Absolute emission fluxes $F_{\rm abs}$, equivalent widths in Å and the ratio of fluxes of the blue (V) to the red (R) emission component, V/R are presented in columns 3-5. Fluxes are in erg cm^{-2}sec^{-1} with the multipliers 10^{-11} for Hα and 10^{-12} for Hβ. Heliocentric radial velocities of profile components are given in columns 6-8 with the errors ±30 km/sec for Hβ and ±20 km/sec for Hα.

Observed profiles of the Hβ and FeII, 4924 Å lines are shown in Figure 2. The ratio $V/R < 1$, and sometimes the "blue" component disappeared completely. Broad absorption wings are recognized at the blue or at the red sides of Hβ components. Average positions of emission components correspond to values: V_r(blue) = -185 ± 6 km/sec and V_r(red) = $+55 \pm 4$ km/sec. Profiles of FeII, 4924, 5018 Å are similar to those of Hβ, although sometimes instead of the emission component, an additional absorption in the FeII profile appeared (see for example, 28.09.2008 and 20.09.2014). The following values are obtained for the narrow absorption in Hβ and FeII: V_r(abs) = -95 ± 5 km/sec and -90 ± 5 km/sec.

Profiles of Hα line vary slightly from date to date. Some examples of profiles are given in Figure 3. The ratio V/R is about 0.35. Disappearance of the blue Hβ component on 03.10.2013 and 17.10.2014, was accompanied by only a small decrease of V/R in the Hα profile. Average positions of Hα components correspond to values: V_r(blue) = -180 ± 3 km/sec, V_r(abs) = -98 ± 2 km/sec and V_r(red) = $+15 \pm 2$ km/sec.

The observed Hβ profile consists of three components: a broad absorption, forming in the stellar photosphere, emission from circumstellar envelope and narrow absorption, formed in the external neutral layers.

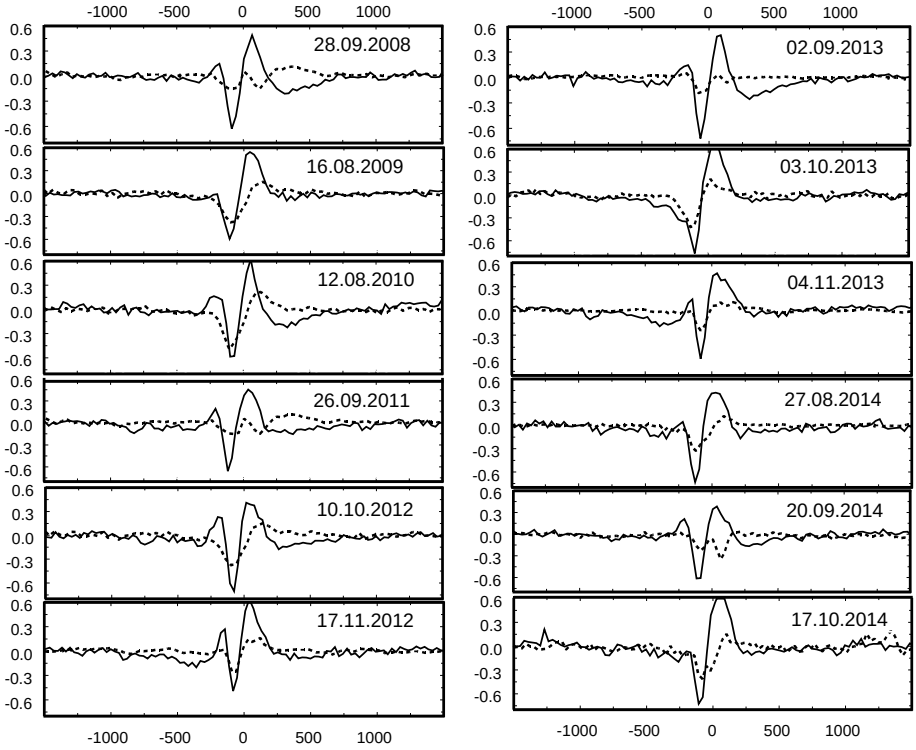

Figure 2. Variation of the Hβ (solid line) and FeII (dashed line) profiles in 2008-2014. X-axis shows heliocentric radial velocity (km/sec), Y-axis gives the ratio $(I_\lambda - I_{\rm cont})/I_{\rm cont}$.

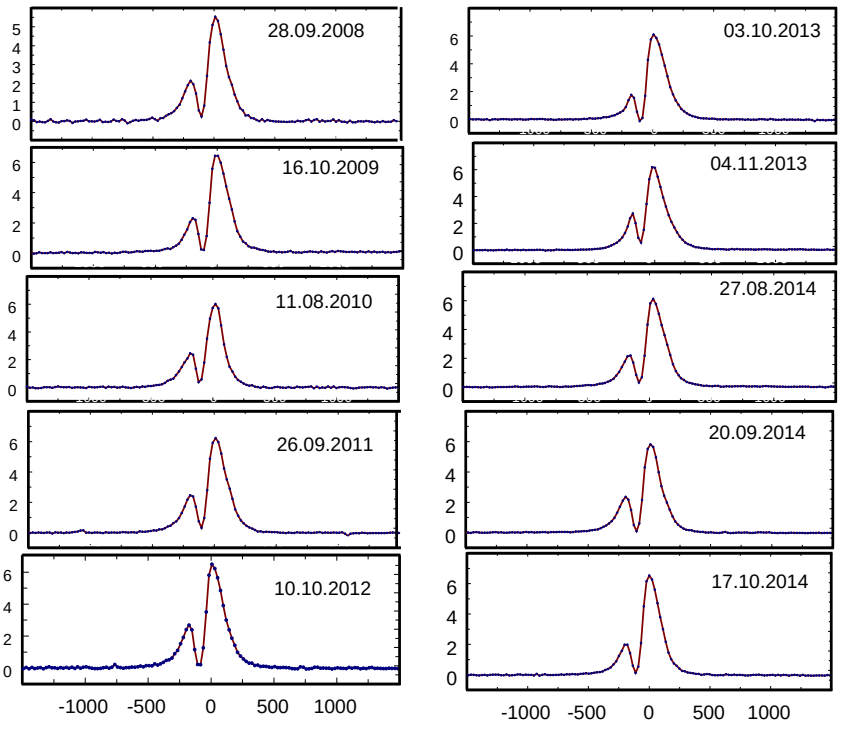

Figure 3. Variation of the Hα profiles in 2008 - 2014. X-axis shows heliocentric radial velocity (km/sec), Y-axis gives the ratio $(I_\lambda - I_{\rm cont})/I_{\rm cont}$.

Table 4: Characteristics of Hα line

HJD	Hα profiles			Radial Velocities of the Hα components		
2400000+	$F_{\rm abs}$	EW	V/R	Emission	Absorption	Emission
	10^{-11}	Å		V		R
54738.146	1.85±0.05	31.2±0.1	0.38	−175	−85	+30
54794.110	1.29±0.20	31.6±0.2	0.40	—	—	—
54801.103	1.07±0.20	33.4±0.1	0.43	−155	−90	+5
55150.196	1.45±0.08	33.1±0.2	0.37	—	—	—
55152.206	1.44±0.08	35.0±0.2	0.36	−185	−110	+5
55421.330	1.22±0.16	31.6±0.2	0.41	−185	−115	+20
55831.256	1.57±0.05	50.8±0.1	0.39	−195	−100	+10
56211.186	1.95±0.02	35.6±0.5	0.41	−175	−95	+6
56538.285	2.04±0.01	31.2±0.2	0.38	−175	−95	+40
56569.190	1.80±0.03	31.5±0.6	0.28	−175	−105	+10
56601.137	1.97±0.03	33.9±0.2	0.44	−160	−90	+10
56896.284	1.25±0.04	32.8±0.1	0.38	−165	−65	+30
56921.235	2.67±0.10	32.8±0.1	0.40	−190	−100	+10
56948.246	1.85±0.02	34.0±0.4	0.30	−195	−110	+5

Radial velocities of the broad Hγ and Hδ absorption lines, in spite of their low accuracy, reflect an orbital motion of the star. However, radial velocities of emission and sharp absorption components of Hβ vary within narrower limits and do not correlate with the variation of the stellar absorption. This suggests that the envelope, which is the source of the emission components and the narrow absorption, does not follow the orbital motion. It is probable that emission lines are formed in the circumstellar environment of the binary.

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