АСТРОФИЗИКА

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NEW Hα EMISSION STARS IN CEP OB3 REGION. A RAPID BRIGHTNESS VARIATION OF V 733 Cep

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A search of emission stars has been done on the base of digitized photographic plates received with 40" Schmidt telescope of Byurakan observatory equipped with a 4° objective prism. 46 new emission stars are found in a small area around the known FU Ori type variable V 733 Cep. Emission stars on the *J - H - H - K* diagram are situated on or in the neighbourhood of T Tau locus. *V, R, I* photometry for some of emission stars is performed as well. Three new variable stars are found in the region. A rapid brightness variation is detected on V 733 Cep.

Key words: Hα *emission stars: Cep OB3 region: V 733 Cep*

1. *Introduction*. Cep OB 3 is one of the youngest star associations [1], situated at the distance of 700 pc [2,3]. The first investigations of this region started in early 1940s [4-6].

Photometric studies of faint members of Cepheus OB3 have been made by some researchers to investigate the structure and star-forming history of this association or its relation to the neighboring molecular clouds. By the first detailed photometric study of Cep OB 3 association 40 early - type objects at a distance 725 pc were found [7]. Later Blaauw found evidence of the existence of two young subgroups - Cep OB3 A and Cep OB3 B, with ages of 8 and 4 Myr, respectively [8]. Based on the study of relative motion an expansion age of 0.72 Myr for these two subgroups has been suggested [9].

Over 50 X-ray point sources were discovered in the region of Cep OB3 with ROSAT PSPC and HRI, the majority of which are probably T Tauri stars [10]. Pozzo et al. [11] identified 10 T Tauri type stars and 6 candidates using *UBVI* photometry and follow-up multi-fiber spectroscopy. Four out of the 10 definite TTS have a ROSAT X-ray counterpart in [10].

Several Hα surveys have been done in this region for last years. Mikami & Ogura (2001) presented a list and finding charts of Hα emission stars in the region of Cep OB3 [12]. Their objective prism survey covered an area of 36 square degrees. They found 108 Hα emission stars, 68 of which are new. 33 new Hα emission stars have been found with the observations of Wide Field Grism Spectrograph (WFGS), attached to the //10 Cassegrain focus of the University of Hawaii 2.2-m telescope [13], and another 149 new Hα

emission stars were revealed in Cep B [14].

It is noteworthy that a new FU Ori type star, V 733 Cep, was discovered in this region in 2004 [15].

The results of above mentioned observations are direct evidence for active star-formation in the Cepheus OB3 region.

In the present work the results of the search and the study of Hα emission stars in the field of Cep OB 3 with the sizes $\alpha_{(2000)} = 22^h51^m45^s - 22^h55^m21^s$ and $\delta_{(2000)} = 62°19'54'' - 62°44'46''$, almost in the center of which is the star V 733 Cep, are presented. The results of photometric study of V 733 Cep and some of Hα emission stars are presented as well.

2. *Observations*. The detailed description of the method of the search of Hα emission stars is given earlier [16]. Search of emission stars is performed on the digitized photographic plates received with 40" Schmidt telescope of Byurakan observatory equipped with a 4° objective prism. The digitization method of the photographic plates is described in detail by Mickaelian et al. [17]. Kodak 103aF plates in combination of an RG 610 filter were used during the observations. The spectral dispersion is 1100 Å/mm at Hα. Three images of the region were obtained with the exposure times 30 min, 60 min and 70 min. The photographed region is a rectangle with size of about 16 square degree, out of which only a small area is used in present search. Observations have been done in 26-28 August 1989. The digitized versions of images expand possibilities of search of the emission and facilitate works with defects of photoemulsion, applying a possibility of variation of the size, brightness and contrast of the image. On Fig.1 the image of a spectrum of a star with strong Hα (a) and the image of a spectrum of a star without emission (b) is presented.

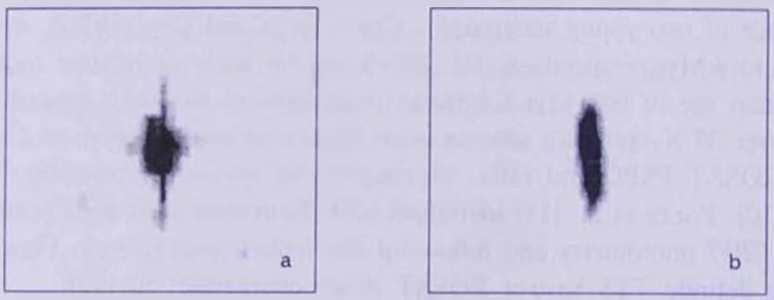

Fig.1. The enlarged images of spectra of a star with strong Hα emission (a) and the spectrum of a star without emission (b).

Photometric study of V 733 Cep and some variable and new emission stars are performed in above mentioned subregion. The observations carried out with 2.6 m telescope of the Byurakan observatory from 1 to 4 December 2008. The

spectral camera SCORPIO was used in observations, description of which has been given earlier [18]. In the period of December 1 to 4, 14 images for the region Cep OB3 with center on V 733 Cep were taken. The integrational time for reception of each image is from 15 to 150 seconds. 11 images of the region were obtained on December 3, during more than two hours. 15 suggested comparison stars were used in our photometric measurements[19,20]. We excluded the stars C, K and F from the list of comparison stars because of their possible variability [20].

The photometry was performed using the IRAF version included in the collection of astronomical softwares UREKA [21] created by the collaboration between Space Telescope Science Institute and Gemini Observatory. We followed the normal reduction procedure using the package of IRAF **noao.imred.ccdred** [22] except for the *R* band frames where the reduction was done without applying the bias substraction to the science images because of their short exposure time. The multiplicative effects of the CCD was corrected using the flats generated from the science images using the tasks provided by the ESO-MIDAS software [23]. The multi aperture photometry was performed using the IRAF **noao.digiphot.apphot** [24] package. We must mention that the photometry images that we have are not enough to realize a very accurate photometry.

3. *New emission stars*. 46 new emission stars are found in the investigated region, which are listed in Table I and are indicated on the finding

Table 1

DATA FOR NEW EMISSION STARS

	α(2000.0)	δ(2000.0)	*J*	*H*	*K*	*I*(Hα)	Ident. (IRAS)
1	2	3	4	5	6	7	8
1	$22^h51^m44'.9$	62°29'29".8	$12^m.742$	$12^m.289$	$12^m.098$	s	
2	22 51 48.63	62 24 55.7	10.451	9.155	8.677	w	
3	22 51 52.3	62 32 00.6	13.178	12.553	12.385	s	
4	22 51 55.53	62 41 45.6	11.637	10.786	10.510	m	
5	22 52 01.16	62 37 06.4	11.067	10.173	9.849	s	
6	22 52 05.61	62 35 34.6	12.567	12.016	11.819	m	
7	22 52 09.72	62 33 17.4	11.773	10.814	10.481	w	
8	22 52 11.67	62 34 10.7	14.228	13.506	13.249	s	
9	22 52 22.19	62 23 40.4	12.021	11.477	11.180	m	
10	22 52 22.71	62 21 50.0	13.029	12.414	12.256	m	
11	22 52 30.79	62 38 27.6	13.51	12.849	12.690	s	
12	22 52 32.75	62 43 36.6				m	
13	22 52 33.9	62 24 15.4	13.005	12.589	12.455	s	
14	22 52 38.37	62 44 12.6	14.166	13.817	13.631	m	
15	22 52 48.51	62 44 23.1	13.548	13.157	12.971	m	
16	22 52 50.13	62 27 34.9	11.851	10.801	9.798	s	R22509+6211
17	22 52 51.25	62 30 43.1	12.669	11.980	11.800	m	
18	22 53 04.84	62 29 30.7	12.343	11.237	10.849	s	

Table 1 (The end)

1	2	3	4	5	6	7	8
19	22 53 13.3	62 42 29.6	13.064	12.557	12.384	w	
20	22 53 15.98	62 30 23.3	13.215	12.560	12.365	s	
21	22 53 19.32	62 25 32.0	13.474	12.985	12.839	m	
22	22 53 22.03	62 22 00.3	13.157	12.429	12.250	s	
23	22 53 34.05	62 23 17.9	13.401	12.746	12.583	s	
24	22 53 49.47	62 35 27.7	11.782	10.781	10.319	w	
25	22 53 52.72	62 34 27.03	12.820	12.372	12.151	s	
26	22 53 55.1	62 33 33.4	12.471	11.518	11.134	s	22519+6217
27	22 53 57.37	62 36 50.6	13.095	12.603	12.478	w	
28	22 53 57.5	62 43 01.2	11.668	10.716	10.429	m	
29	22 53 58.99	62 35 39.0	11.742	11.003	10.653	m	
30	22 54 03.76	62 41 19.9	13.179	12.304	12.009	s	
31	22 54 06.58	62 36 49.8	13.41	12.755	12.612	w	
32	22 54 17.98	62 42 33.1	12.132	11.195	10.882	m	
33	22 54 18.46	62 26 46.2	12.768	12.259	12.022	m	
34	22 54 21.23	62 43 48.3	11.574	10.332	9.907	s	
35	22 54 22.75	62 25 05.2	12.510	11.683	11.407	m	
36	22 54 24.07	62 35 16.4	11.801	11.019	10.733	m	
37	22 54 24.64	62 25 05.0	13.829	13.253	13.128	s	
38	22 54 26.35	62 42 37.3	13.173	12.423	12.185	m	
39	22 54 31.75	62 22 53.3	12.538	11.881	11.583	s	
40	22 54 38.53	62 41 35.5	13.619	13.106	12.968	w	
41	22 54 40.63	62 33 33.9	11.224	10.423	10.157	s	
42	22 54 47.54	62 39 59.8	13.464	12.990	12.868	m	
43	22 54 49.78	62 30 12.4	11.859	10.608	10.163	w	
44	22 54 56.71	62 39 36.6	12.901	12.489	12.407	w	
45	22 55 00.75	62 35 22.3	11.906	10.743	9.987	w	
46	22 55 16.3	62 33 56.8	12.788	11.778	11.403	w	

charts (see Fig.2). In Table 1, the first column gives the serial numbers with which the stars are identified on the finding charts. The 2000.0 right ascensions and declinations are given in the second and third columns, respectively. The coordinates of the stars had been determined after the identification on the Palomar Sky Survey atlases. In the columns 4-6 the *J*, *H*, *K* magnitudes for the stars, taken from 2MASS observations [25] via the Vizier catalogue access tool, are presented. In the column 7 it is appointed the relative intensities of the emission line $I_{H\alpha}$ estimated on basis of objective prism spectra (*s*-strong, *m*-middle, *w*-weak). In the last column (ident.) presents the results of identification with infrared sources.

Comparison of our results with the results of Hα surveys performed in Cep OB3 [12-14] shows, that only one known emission star - No 28 [12] is situated in the studied region. The careful study of the objective prism spectra

did not allow us to detect even weak trace of emission on the spectrum of this star. Probably the line intensity of this star has a variable character.

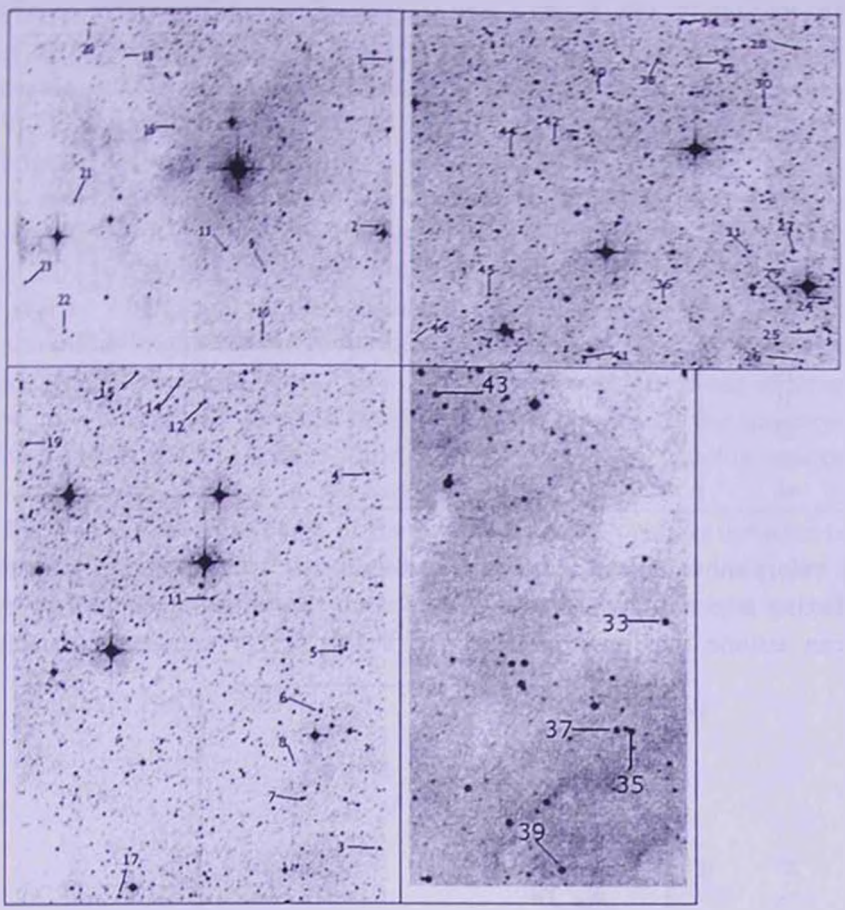

Fig.2. Finding charts of new emission stars.

Table 2 presents the results of *VRI* photometry for 14 emission stars. In the first column of Table 2 the number of Hα emission star is given (see Table 1). In the following columns the magnitudes in *V*, *R*, *I* colors are attached. As one can see, the red magnitudes for these stars are measured in two different days.The errors of photometric measurements fall within the range of $\sigma(V) = 0^{m}.02 - 0^{m}.04$, $\sigma(R) = 0^{m}.03 - 0^{m}.06$ (Dec.1), $\sigma(R) = 0^{m}.04 - 0^{m}.09$ (Dec.3) and $\sigma(I) = 0^{m}.01 - 0^{m}.03$ (Dec.1).

In Fig.2 the finding charts of new emission stars are presented, where the red images from SDSS are used. North is at the top and east is to the left.

Fig.3 presents near *IR* color-color diagram for 45 emission stars from Table 1. On Fig.3 the locus of classical T Tau stars [26], and the main sequence, constructed with the data from [27] are shown by the arrows. *J* - *H* and

Table 2

THE RESULTS OF *V, R, I* PHOTOMETRY 14 EMISSION STARS

No (Hα)	*R*(Dec.1)	*R*(Dec.3)	*V*	*I*
16	15".76	15".71	16".82	
17	16.01	15.95	17.11	14".02
18	16.54	16.53	17.71	15.17
20	16.15	16.15	17.54	14.54
21	16.11	16.05	17.63	
24	15.23	15.69	16.8	14.19
25	15.8	15.84	17.04	13.62
26	16.35	16.34	17.61	
27	15.76	15.75	17.41	14.17
29	15.41	15.44	16.8	13.88
31	16.16	16.15	17.63	14.7
33	16.23	16.19	17.55	
36	15.54	15.47	16.79	13.97
41	14.92	14.88		

H - K colors show that all these stars belong to the spectral classes later than K0. Taking into account also the existence of Hα emission in their spectra, one can assume that most of them are T Tau or UV Ceti type variables.

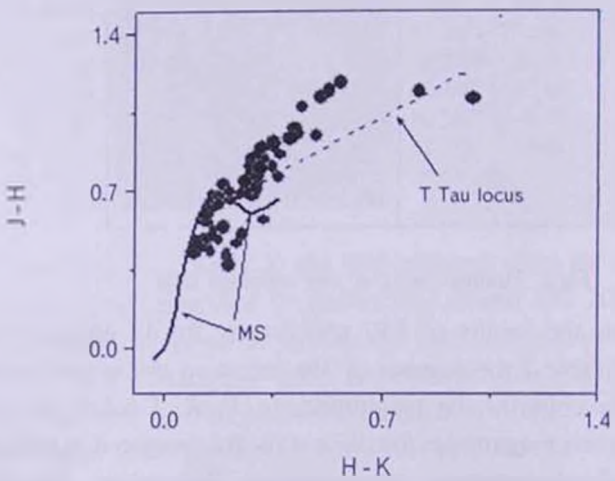

Fig.3. Emission stars on the *J - H - H - K* diagram.

4. *V 733 Cep*. V 733 Cep is one of the known FU Ori type stars discovered in 2004 by Persson [15]. Nowadays, only 10 stars are recognized as FU Ori type variables [28] among more than 47000 variable stars presented in GCVS. Such a rare form of variability once again indicates the importance of their study. The important role that FU Ori type variables play in the stellar evolution has been pointed out in the early seventies of the last century [29].

The star V 733 Cep is situated almost in the center of the studied region. The magnitudes of discovered Hα stars in red band lie in range from 13^m to 17^m. On the objective prism images even a faint trace of this star had not been detected. Consequently, the star V 733 Cep in the observed period is fainter than 17^m in red band. Photometric data from the photographic observations of V 733 Cep also shows, that the star in September 1989 was in low level of brightness ($m_B = 20^m.9$) [20].

A rapid brightness variation was detected on V 733 Cep on December 3, 2008. A detail BVRI photometric study has been done for V 733 Cep from June 2007 to October 2009, where a slow trend of brightness decrease ($0^m.15$ per year in I band and $0^m.23$ per year in V band) was observed [20]. It must be noted that brightness variations exceeding the value $0^m.2$ were not detected during the observational period 2007-2009 [20]. The results of our observations show, that, out of this detected rapid increase of brightness, the magnitude of V 733 Cep has almost constant value, $m_R = 16^m.39 \pm 0^m.05$, which is concordant with the results obtained in R band earlier [19,20].

Fig.4 shows the light curve of the brightness variation. The duration of the increase in brightness is less than 30 min and in December 4 the star again shows its quiescent brightness. Such kind of short term brightness increase on

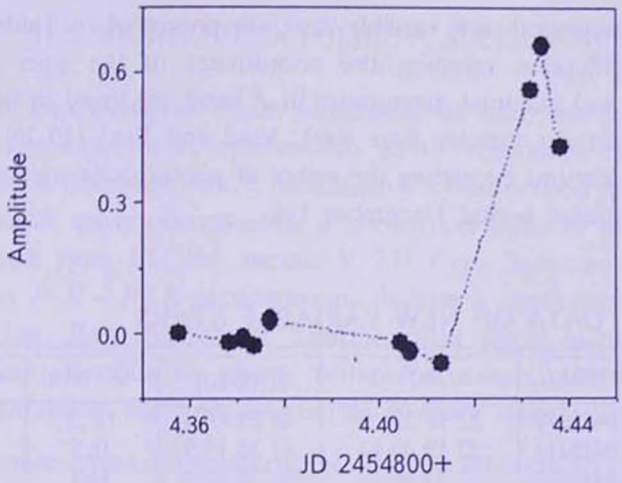

Fig.4. Light curve of detected brightness variation of V 733 Cep.

FU Ori type variables is detected for the first time. Spectral classification of V 733 Cep based on the spectral appearance in the red band indicates that its spectral type lies between early to mid G, while the spectral characteristics in infrared gives a late spectral type M7-M8 [30]. The light curve of rapid variation by the shape, amplitude and duration is typical to those of UV Ceti type flare events. Probably the rapid variation of V 733 is a possible "superflare", similar to those detected on stars of spectral types F8-G8 during last years [31].

5. *Variable stars*. During the study of mentioned region, 3 new variable stars are found. One of these stars is listed in Tables 1 and 2 as Hα emission star No 24 and shown in Fig 2. Both other variables, *a* and *b*, are shown in Fig.5. Finding charts were taken from the direct images of the region in red band, received in December 2008 with the 2.6m telescope.

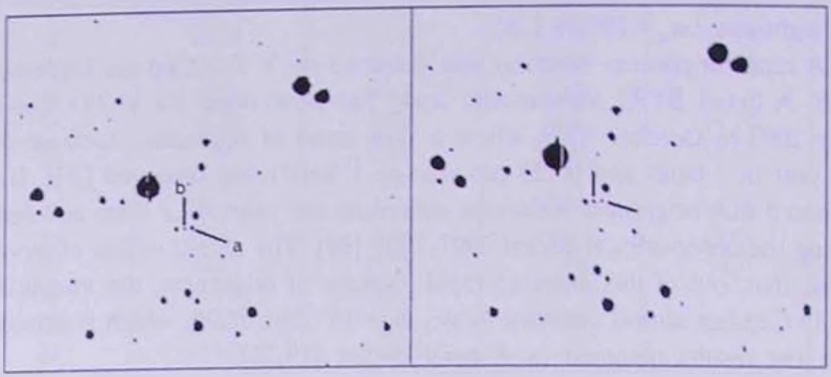

Fig.5. Finding chart of two new variable stars a and b. Images taken from our observations on Dec. 1 (left), and Dec. 3 (right).

The data of discovered new variable stars are presented in Table 3. The USNO-B1.0 identification number, the coordinates of the stars and the observed minimal and maximal magnitudes in *R* band are listed in the Table. It is remarkable that the variable stars Var1, Var2 and Var3 [19,20] did not show brightness variations exceeding the errors of photometric measurements during the observational period December 1-4.

Table 3

DATA OF NEW VARIABLE STARS

Star	USBO-B1.0	α(2000.0)	δ(2000.0)	*mR* (min)	*mR* (max)
No 24(Hα)	1523-0425379	$22^h52^m22^s.19$	62°23'40".4	$15^m.7$	$15^m.2$
A	1525-0418411	22 53 49.83	62 35 19.9	16.5	15.8
B	1525-0418422	22 53 50.56	62 35 19.3	14.9	14.3

6. *Summary*. The results of objective-prism Schmidt survey of Hα emission stars have been carried out in a small area of Cep OB3 association with the center of FU Ori type variable V733 Cep. 46 new emission stars have been found in this field. The stars are identified on POSS atlases, on which their coordinates have been determined. The Hα emission intensities are estimated relative to continuous spectra. Finding charts of emission stars are presented as well. The *J - H – H - K* color-color diagram is made for emission stars, which shows that most of them could be T Tau and UV Ceti types

variable stars belonging to the spectral classes later K0.

A rapid brightness variation is detected on V 733 Cep on December 3. Such short time flare like event on FU Ori type variables is detected for the first time.

Three new variable stars are discovered in this region. The future investigations are need for the determination of the nature of their variability.

The results of our study once more confirm that Cep OB3 association is one of the youngest star forming regions.

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НОВЫЕ Hα ЭМИССИОННЫЕ ЗВЕЗДЫ В ОБЛАСТИ CEP OB3. БЫСТРОЕ ИЗМЕНЕНИЕ БЛЕСКА ЗВЕЗДЫ V 733 CEP

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Поиск эмиссионных звезд выполнен на базе оцифрованных фотографических пластинок, полученных на 40" телескопе системы Шмидта Бюраканской обсерватории, с помощью 4° объективной призмы. 46 новых эмиссионных звезд обнаружены в крохотной области вокруг известной переменной типа FU Ori звезды V 733 Cep. Эмиссионные звезды на диаграмме $J-H-H-K$ расположены на/или в окрестности локуса звезд типа T Tau. Для некоторых эмиссионных звезд выполнена V, R, I фотометрия. В области обнаружены три новые переменные звезды. Зарегистрировано быстрое изменение яркости звезды V733 Cep.

Ключевые слова: Hα *эмиссионные звезды: область Cep OB3: V 733 Cep*

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