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MK classification of four visual binary stars with variable components

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Abstract. Slit spectra of 8 components in 4 visual binary systems (UU Psc, YZ Cas, RS Tri and BX And) whose primaries are eclipsing binaries are studied. For the first time MK classification has been made for their secondary components showing that they all belong to the main sequence stars later than F5. In all probability, UU Psc is merely an optical pair with a visual companion.

Key words: stars: binaries: visual – stars: MK classification

1. Introduction

The study of variable stars as a whole forms one of the major branches of stellar astronomy, providing us with additional parameters (time scales, amplitudes etc.) which are not available for non-variable stars. A variable star being a component of a visual binary (VB) is of special interest because we deal with a physical system of two stars with equal initial age and chemical composition but which are likely to be presently at different stages of their evolution.

Can one be certain that a VB system undergoing their evolution process does not suffer concomitant orbit evolution?

Does its present orbit keep the traces of the physical evolution of the components?

Do any significant differences exist in astrophysical and orbital parameters between visual binaries with variable components (hereafter VBVC) and other, much more numerous VBs whose components do not exhibit light variations?

These and many other questions concerning the origin and evolutionary tracks of VB stars still remain unclear because of the permanently voiced (Dommanget, 1988; 1997) lack of information on their basic astrophysical parameters in general, and for those with variable components in particular. Despite many efforts to collect spectral data on VBs by Meisel (1968, and references therein for earlier articles), Murphy (1969), Bouige (1974), Levato (1975), Lutz and Lutz (1977), Abt (1981; 1985), Gahm et al., (1983), Lindroos (1985), Chambliss (1992) and others, we still lack information on such an important parameter as their MK spectral class. Abt (1985) clearly demonstrated the lack of spectral information even for relatively bright stars from ADS catalogue (Aitken, 1932) as well as many reasons to obtain their MK types through classification based on slit spectra, namely to provide spectroscopic distances; to learn whether or not the system is physical; to identify stars of unusual interest etc. Important statistical studies can also be performed when a homogeneous astrophysical data sample is collected. Once gathered, such data should then be used for the comparative study of their astrophysical and orbital properties both to improve our knowledge of masses, radii, luminosity etc. and to learn more on the structure and evolution of stars and stellar systems.

The catalogue of the multiple stars, which has recently been published (Tokovinin, 1997), has improved and systematized the work on measuring multiple systems the overwhelming majority of which are physical. Three systems, UU Psc, YZ Cas and BX And, out of four presented in our paper are included in the catalogue of Tokovinin (1997).

We present in this paper the MK classification of 8 components in 4 VBVC from the catalogue of visual double stars with variable components published by Proust et al. (1981) whose main components are eclipsing binaries. The classification is based on their slit spectra obtained for the first time for their visual companions. The spectra of the main components have been obtained both for comparison purposes and to complement the already known data on their variability.

2. Observations

All observations were made in November, 1995 on the 6 m telescope of the Russian Special Astrophysical Observatory using a long-slit spectrograph installed in the prime focus + CCD 580 × 380, as described in Afanasiev et al. (1995), resolution 3–4 Å, as well

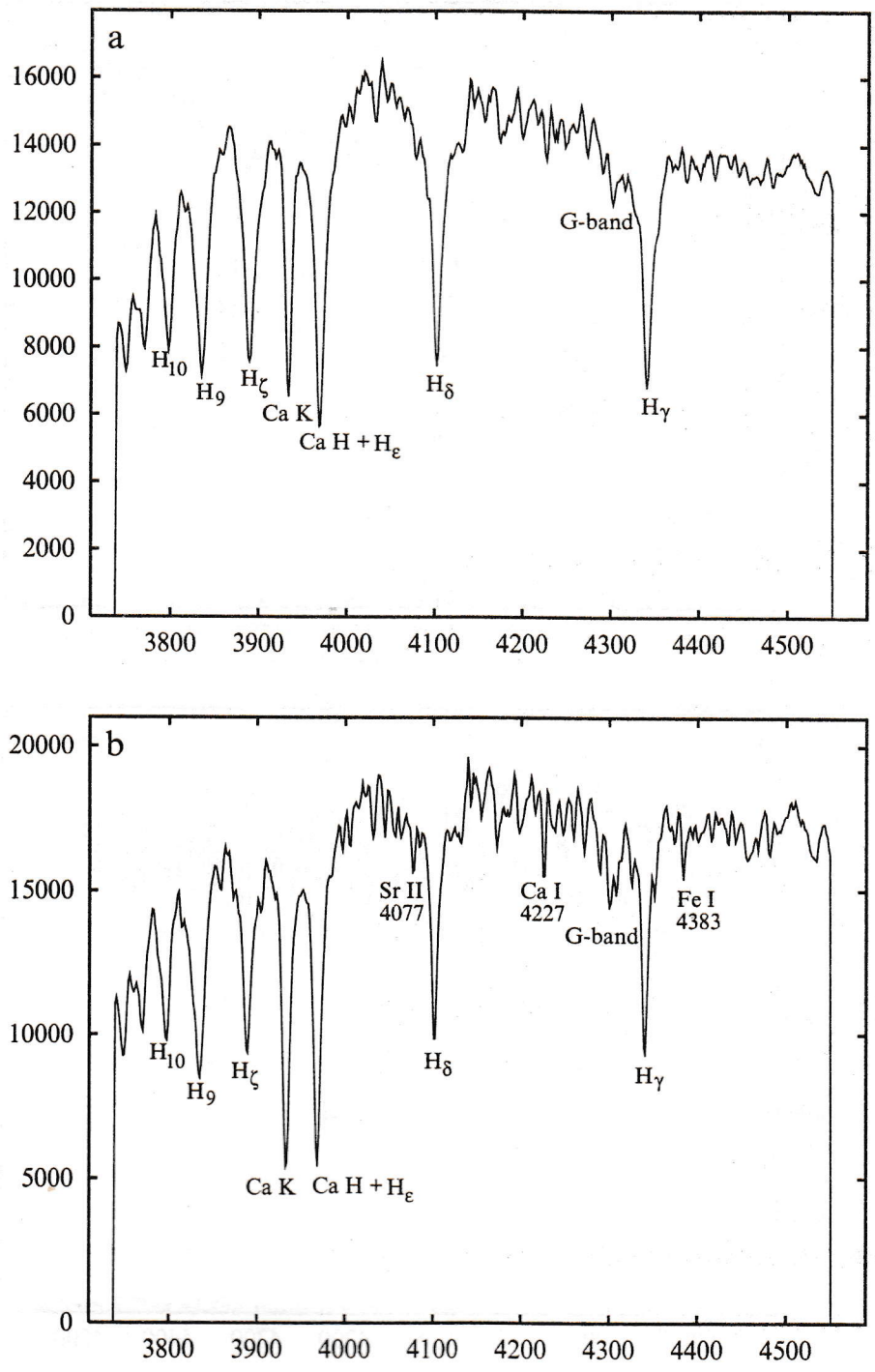

Figure 1: *UU Psc: a) the main component spectrum; b) visual companion spectrum.*

as on the 1.22 m telescope of Asiago Astrophysical Observatory in Italy (prism spectrograph camera VI + CCD 512 × 512, resolution 3 Å at H_γ).

A spectral range of 3750–5200 Å was covered by two exposures in the ranges 3750–4550 and 4500–5200 Å. All the necessary corrections (bias, dark current etc.) were made using a standard IRAF package. Aperture extraction was performed following the optimal method implemented in IRAF by Horn (1986). Twenty standard lines of Fe and Ne taken from Tomov and Munari (1995) were used for the wavelength correction of spectra obtained on the 1.22 m telescope. More details on the 6 m telescope observations and data reduction can be found in Vlasyuk (1993). The stars from Stone's list (1977) were observed as standards.

Careful estimation shows that on the spectra the

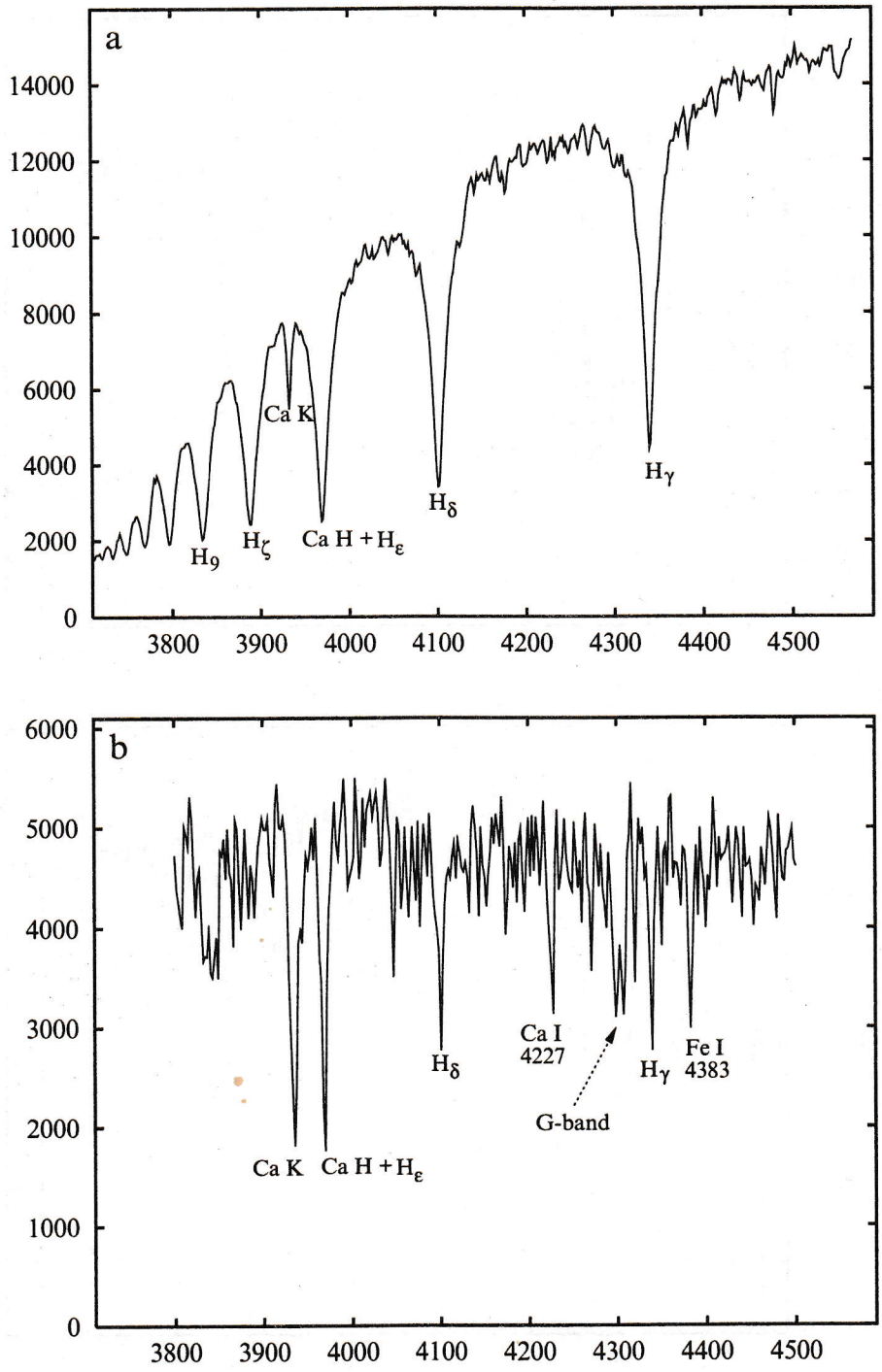

Figure 2: *YZ Cas: a) the main component spectrum; b) visual companion spectrum.*

absorption lines with equivalent width W > 0.3 Å can be reliably identified with a standard photometric error of 15–20 %. All absorption lines mentioned in the next section and used for classification purposes satisfy the above mentioned criteria.

All data on observations are presented in Table 1. The spectra in the range 3750–4550 Å obtained with the 6 m telescope (except that for the visual companion of YZ Cas, which was obtained on the 1.22 m telescope at Asiago) are displayed in Figs. 1–4, wherein the intensity is given in arbitrary units and wavelength in angstroms.

3. MK classification

All spectra obtained for each star on different telescopes were carefully compared in order to identify

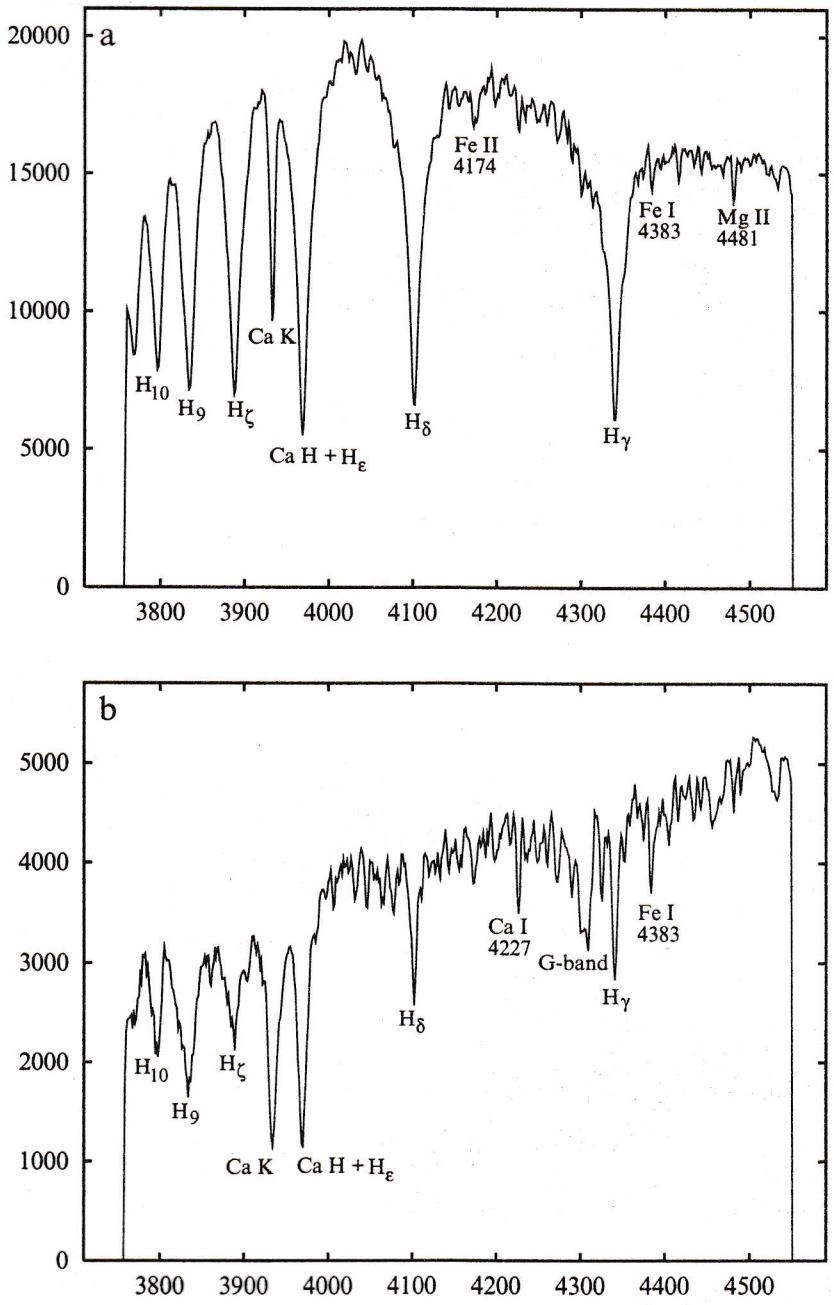

Figure 3: *RS Tri: a) the main component spectrum; b) visual companion spectrum.*

the spectral lines surely detected in the spectrum. Only relatively strong representative lines (see comments on individual objects given in the next section) indicated by Jaschek and Jaschek (1987, 1995) were considered for classification purposes. We used "An atlas of stellar tracings" by Goy et al. (1995), which covers all spectral classes and luminosity types, being the most complete available atlas of spectra tracings including those of fundamental standards in the MK system. We followed mainly the criteria mentioned by Jaschek and Jaschek (1987, 1995) and Yamashita et al. (1977) for classification purposes as the latter Atlas contains the spectra with a dispersion very close to that obtained in the present work. The classification is presented in Table 2 where the previous data are also given for comparison.

From the data presented in Table 2 one can see that our classification differs by 3 spectral subtypes only for BX And, which could be explained by the variable character of its spectra, as noted by Hill et al. (1975), while in all other cases the classification remains well concordant and the differences do not exceed one subtype. As regards luminosity classes, they are very close or coincide with the previous data,

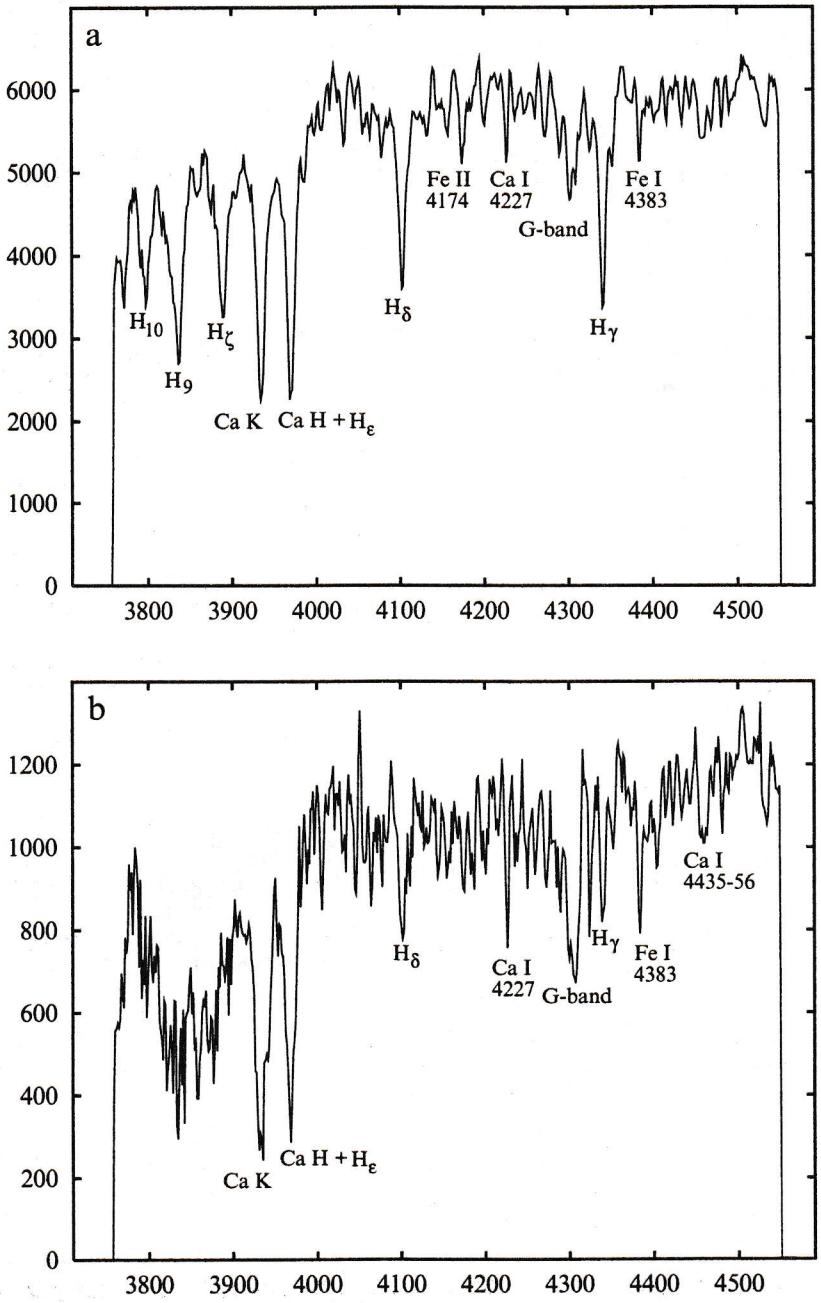

Figure 4: *BX And: a) the main component spectrum; b) secondary companion spectrum.*

always remaining within the usual error of 0.6 class (Jaschek and Jaschek, 1987). Thus, comparison with the previously published MK types for main components shows that our classification agrees fairly with the others. In continuation some comments on individual objects are given.

4. Comments on individual stars

UU Psc. The Balmer lines from H_β to H_{12} are well seen in the spectra of the main component (Fig. 1a). The intensity of CaII K is certainly lower than CaII H + H_ϵ. CaI 4227, G-band and other metallic lines are weak, indicating early F types. There are no peculiar features regarding its luminosity class, so this star surely belongs to the main sequence.

In the spectra of the visual companion (Fig. 1b) hydrogen lines are still well seen, but the CaII K intensity becomes practically equal to CaII H + H_ϵ. Apart from that, CaI 4227, G-band and other metallic lines (for instance, FeI 4383) are stronger and better seen (comparing to those belonging to the main component) indicating with certainty the later subtype while within the F spectral type.

Table 1: *Main observational data*

Name	Coordinates (2000.0) alpha	delta	HD, BD	ADS	Date	Telescope	Exp.-Range (sec)
UU Psc	00 14 59	+08 49 17	1061	191 A	18.11.95	1.22m	200-R1; 500-R2
				191 A	29.11.95	6m	15-R1; 15-R2
				191 B	18.11.95	1.22m	900-R1; 1200-R2
				191 B	29.11.95	6m	180-R1; 180-R2
YZ Cas	00 45 39	+74 59 18	4161	624 A	19.11.95	1.22m	600-R1;
				624 A	30.11.95	6m	120-R1; 120-R2
				624 B	19.11.95	1.22m	3600-R1;
S Tri	01 34 49	+29 35 21	+28 258	1236 A	29.11.95	6m	60-R1; 300-R2
				1236 B	29.11.95	6m	300-R1; 1200-R2
BX And	02 09 04	+40 47 39	13078	1671 A	29.11.95	6m	600-R1; 600-R2
				1671 B	29.11.95	6m	600-R1;

Column 1 : Bayern name of the star
Columns 2,3: Right ascension and declination for the epoch 2000.0
Column 4 : HD or BD number
Column 5 : ADS number from Aitken's (1932) catalogue
Column 6 : Observation date
Column 7 : Telescope aperture
Column 8 : Exposure time (sec) and spectral range: R1 — 3750–4550 Å, R2 — 4500–5200 Å

Table 2: *MK classification of the observed stars*

Name	V	Var. type	Sep. (sec.)	MK classification: This paper	MK classification: Other classifications
UU Psc	6.05	Algol	11".6	F0 V	F0IV-F4V (Cowley and Fraquelli, 1974) F0 V (Levato, 1975)
Second.	7.7			F5 IV-V	—
YZ Cas	6.12	Algol	36.1	A2 IV-V	A2 IV (Abt and Bidelman, 1969) A1 V (Hill et al., 1975)
Second.	9.7			G0 V	—
RS Tri	11.00	Algol	5.0	A4 V	A5 V (Lampens, 1996)
Second.	11.2			F6 V	—
BX And	9.57	W UMa	19.6	F5 V	F2 V var. (Hill et al., 1975)
Second.	10.7			G5 V	—

Column 1 : Bayern name of the star
Column 2 : Visual V magnitude at minimum (GCVS) for variable (main) component, for secondaries the magnitudes are taken from Proust et al. (1981)
Column 3 : Type of variability
Column 4 : Separation (arcsec) taken from Proust et al. (1981)
Column 5 : MK types as defined by authors
Column 6 : Other MK types and corresponding references

The presence of the weak SrII 4077 line makes somewhat uncertain the luminosity class since in normal dwarfs it does not appear, meanwhile in subdwarfs it must be stronger.

YZ Cas. The spectra of the main component (Fig. 2a) correspond to the typical main sequence early A type with the strongest Balmer lines and weak CaII K and other metallic lines. In contrast with the main component, the visual companion (Fig. 2b) shows a strong CaII K line, G-band, CaI 4227, other metallic lines of Fe, Mg, Ti etc., and can surely be classified as GO V. The Balmer lines are still seen but they are much weaker than metallic ones.

RS Tri. The main component (Fig. 3a) is a typical

A-type star where hydrogen lines clearly dominate the spectra. The intensity of CaII K is about half that of CaII H + H_ϵ.

In the spectra of the visual companion (Fig. 3b) the Balmer lines are still well seen but the CaII K line intensity becomes almost equal to that of CaII H+ H_ϵ. CaI 4227 and the G-band are relatively strong, the equivalent width of the G-band is certainly higher than that of H_γ. FeI 4383 is well seen in the spectrum.

From the difference of apparent magnitudes ($0^m.2$) and corresponding spectral classes (F5 V and G5 V) it is obvious that the system is merely an optical pair.

BX And. As it was mentioned above, our classification (F5 V) differs by 3 subclasses from that (F2 V) described by Hill et al. (1975). A careful comparison with the tracings of the standard stars allows us to classify the primary as F5 mainly owing to the intensity of the G-band, CaI 4227 and FeI 4383 lines which are strong enough in comparison with hydrogen lines (Fig. 4a), thus indicating for certain the spectral type later than F2. It is worth noting that the CaII H+Hϵ line has practically the same intensity as CaII, which is another evidence of the late F subtype.

As it was mentioned above, our classification (F5 V) differs by 3 subclasses from that (F2 V) described by Hill et al. (1975). Note, however, that such a difference may be explained by the variable character of its spectrum pointed out by Hill et al. (1975).

The strongest feature in the spectrum of the visual companion is the G band, CaII H and K, CaI 4227 and different metallic lines (for instance, Fe I 4383) are very strong, whereas the hydrogen lines are weak, although clearly visible (Fig. 4b). All these features show that it can be classified as G5 and that it belongs to the main sequence.

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References

Abt H.A., 1981, Astrophys. J. Suppl. Ser., **45**, 437
Abt H.A., 1985, Astrophys. J. Suppl. Ser., **59**, 95
Abt H.A., Bidelman W., 1969, Astrophys. J., **158**, 1091
Afanasiev V.L., Burenkov A.N., Vlasyuk V.V., Drabek S.V., 1995, SAO Technical report No. 234
Aitken R.G., 1932, New General Catalogue of Double Stars Within 120 deg. of the North Pole, Washington, DC, Carnegie Institute
Bouige R., 1974, Vistas Astron., **16**, 117
Chambliss C., 1992, Publ. Astr. Soc. Pacific, **104**, 663
Cowley A., Fraquelli D., 1974, Publ. Astr. Soc. Pacific, **86**, 70
Dommanget J., 1988, Astrophys. Space Sci., **142**, 5
Dommanget J., 1997, ASSL, **223**, 403
Gahm G.F., Ahlin P., Lindroos K.P., 1983, Astron. Astrophys., **51**, 143
Goy G., Jaschek M., Jaschek C., 1995, An atlas of stellar tracings, Geneva Observatory
Horn K., 1986, Publ. Astr. Soc. Pacific, **98**, 609
Hill G., Hilditch R.W., Younger F., Fisher W.A., 1975, Mem.RAS, **79**, 131
Jaschek C., Jaschek M., 1987, The Classification of Stars, Cambridge Univ. Press, Cambridge
Jaschek C., Jaschek M., 1995, The Behaviour of Chemical Elements in Stars, Cambridge Univ. Press, Cambridge
Kholopov P.N., Samus' N.N., Frolov M.S., Goranskij M.P., Gorynya M.P., Kireeva N.N., Kukarkina N.P., Kurochkin N.E., Medvedeva G.I., Perova N.B., Shugarov S.Yu., 1982–1987, General Catalogue of Variable Stars, (GCVS), I-III, Nauka Publ. House, Moscow, 4th ed.
Lampens P., 1996 (private communication)
Levato H., 1975, Astron. Astrophys. Suppl. Ser., **19**, 91
Lindroos K.P., 1985, Astron. Astrophys. Suppl. Ser., **60**, 183
Lutz T.E., Lutz J.H., 1977, Astron. J., **82**, 431
Meisel D.D., 1968, Astron. J., **73**, 350
Murphy R.E., 1969, Astron. J., **74**, 1082
Proust D., Ochsenbein F., Pettersen B.R., 1981, Astron. Astrophys. Suppl. Ser., **44**, 179
Stone R.P.S., 1977, Astrophys. J., **218**, 767
Tokovinin A.A., 1997, Astron. Astrophys. Suppl. Ser., **124**, 75
Tomov T.V., Munari U., 1995, Padova and Asiago Obs. Techn. Rep. No.9
Vlasyuk V.V., 1993, Bull. Spec. Astrophys. Obs., **36**, 107
Yamashita Y., Nirai K., Norimoto Y., 1977, An atlas of representative stellar spectra, University of Tokyo Press