COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5810

Konkoly Observatory
Budapest
8 January 2008

HU ISSN 0374 – 0676

NEW VARIABLE STAR IN THE FIELD OF THE SEYFERT GALAXY MRK 290

DOROSHENKO, V. T.[1,2]; SERGEEV, S. G.[2]; EFIMOV, YU. S.[2]; KLIMANOV, S. A.[2]; NAZAROV, S. V.[2]

[1] Crimean Laboratory of Sternberg Astronomical Institute, Nauchny, 98409, Crimea, Ukraine; e-mail: vdorosh@sai.crimea.ua; dorvalen@mail.ru

[2] Crimean Astrophysical Observatory, Nauchny, 98409, Crimea, Ukraine; e-mail: sergeev@crao.crimea.ua; efimov@crao.crimea.ua; sergdave2004@mail.ru; nazarastron2002@mail.ru

We announce the discovery of a new variable star in the field of the Seyfert galaxy Mrk 290 (star 9 in Fig. 1). The CCD monitoring was made in the BVR_cI_c bands with the 70-cm telescope of the Crimean Astrophysical Observatory over 62 nights from 20.03.2007 to 17.07.2007. We used the CCD AP7p camera with a field size of 515 × 512 pixels. The field of view of our images was $15' \times 15'$. Typically, for each observational night we obtained four images in each filter with a sampling time of about 10 min. The BVR_cI_c photometry of objects in the Mrk 290 field was made with the aperture $A = 12''$. We also observed the Seyfert galaxies NGC 3227, NGC 3516, NGC 4051, and NGC 5548 over the same nights. Some stars in the fields of these galaxies were calibrated earlier by Doroshenko et al. (2005), and we used them as secondary standards for the stars around Mrk 290.

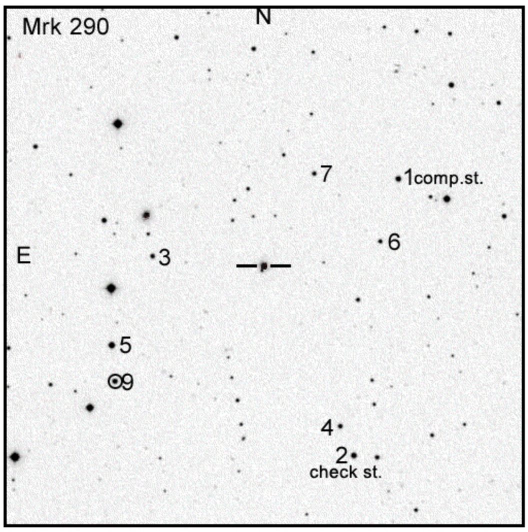

Figure 1. $14'\times14'$ finding chart for the variable star 9 (marked by an open circle), the comparison star (No. 1), and control stars (No. 2, 3, 4, 6, 7). The Seyfert galaxy Mrk 290 is marked by two lines.

For accurate photometry it is important to search for possible variable stars among the reference star candidates. We used the χ^2 criterion to single out the variable stars.

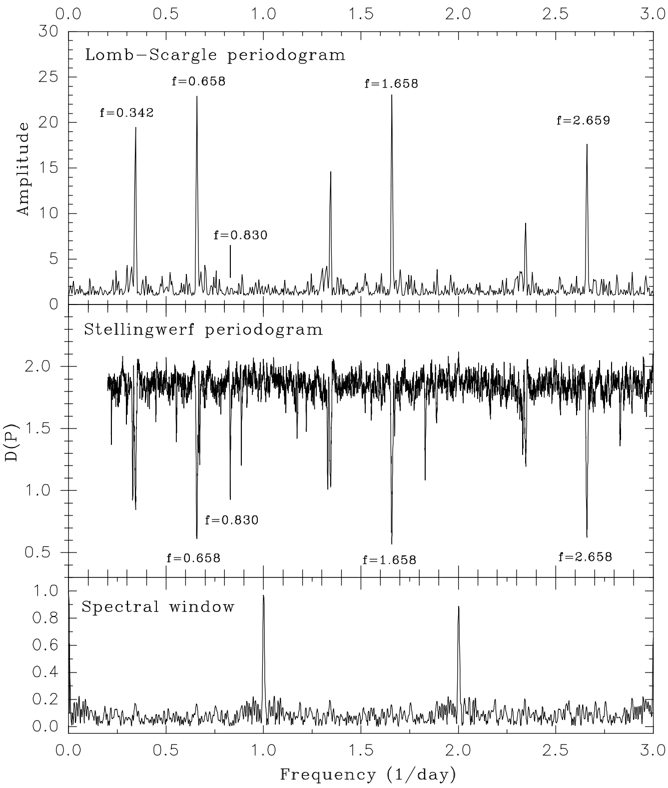

Figure 2. The Lomb-Scargle periodogram (upper panel), Stellingwerf periodogram (middle panel), and the spectral window (bottom panel) obtained from the nightly average observational data on star 9 in the B band.

We computed the light curves for each selected star and calculated the χ^2 value per one degree of freedom as well as the confidence level for the $\chi^2 \leq 1$ hypothesis. If the star under consideration is not variable, χ^2 is close to 1 in each filter. For variable stars χ^2 should be significantly greater than 1. For star 9 χ^2 per dof was equal to 11.512, 20.174, 21.389, and 9.964 in the BVR_cI_c bands, respectively. So, star 9 turns out to be a variable with high confidence level. Stars 1, 2, 3, 4, 6, and 7 are not variable stars, as $\chi^2 \leq 1$. Star 5 is a possible variable star, since for this star χ^2 was equal to 2.552, 3.147, 3.015, and 1.666 in the B, V, R_c, I_c bands, respectively. Table 1 lists the BVR_cI_c magnitudes of stars 1-7. Stars 3, 4, 6, and 7 can be used as control stars in addition to star 2 inasmuch as they are not variables. Observations, processing, and photometric uncertainties were described in more detail by Doroshenko et al. (2005).

Table 1. BVR_cI_c photometry of stars in the field of Mrk 290

Star	B	er.B	V	er.V	R_c	er.R_c	I_c	er.I_c
1	14.926	0.008	14.078	0.015	13.600	0.009	13.188	0.011
2	14.599	0.008	13.880	0.006	13.466	0.006	13.061	0.006
3	15.616	0.010	15.075	0.008	14.731	0.007	14.431	0.007
4	16.138	0.012	15.213	0.009	14.648	0.007	14.143	0.008
5	14.514	0.009	13.461	0.008	12.836	0.007	12.328	0.006
6	16.086	0.013	15.470	0.009	15.091	0.006	14.748	0.010
7	16.094	0.012	15.454	0.010	15.059	0.006	14.675	0.008

Star 9 is listed as 1478-0314015, RA=$15^h36^m22^s.56$, D=$+57°50'53''.9$ (J2000.0), b=$47°.9$ in the NOMAD1 catalog (Zacharias et al., 2004). The reddening map by Schlegel et al. (1998) implies that $E(B-V) \leq 0^m.013$. Table 2 gives the photometry of star 9 in the Johnson-Cousins BVR_cI_c system. Figure 3 shows the observed light curves of star 9 and control star 2 (two upper plots).

The Lomb-Scargle periodogram analysis of the nightly average BVR_cI_c light curves (Fig. 2) revealed high peaks at the frequencies f=0.342, 0.659, 1.659, 2.659, etc. c/d. The most significant frequency is f=1.659 c/d, although the frequency peak at f=0.659 c/d is only a little bit lower. The spectral window shows peaks at the frequencies f=1.001, 2.001, 3.001, etc. c/d. If the actual period corresponds to f=1.659 c/d, the peaks with f=0.659 and 2.659 c/d can be considered as alias peaks due to resonance f=1.659 c/d with fw=1.001 c/d. However, if the actual frequency of variability is f=0.659 c/d, the resonance frequencies should be f=0.342 and f=1.659 c/d, respectively. Almost the same periods (Fig. 2) were revealed with the use of the Stellingwerf periodogram calculated by means of the software developed by Pelt (1992). The phased light curves with P=1.518 d (f=0.659 c/d) and P=0.603 d (f=1.659 c/d) are almost sinusoidal and have much in common (Fig. 3, two bottom plots). So, the true period is very difficult to determine. It is quite possible that the variable star belongs to short-period eclipsing binaries. In this case the orbital period is P=1.205 d, the hypothetic primary and secondary minima of this system have equal depths, and they are indistinguishable from each other in BVR_cI_c bands (see Fig. 4). The phase curve with P=1.518 d does not contradict the idea of a single fast-rotating spotted star.

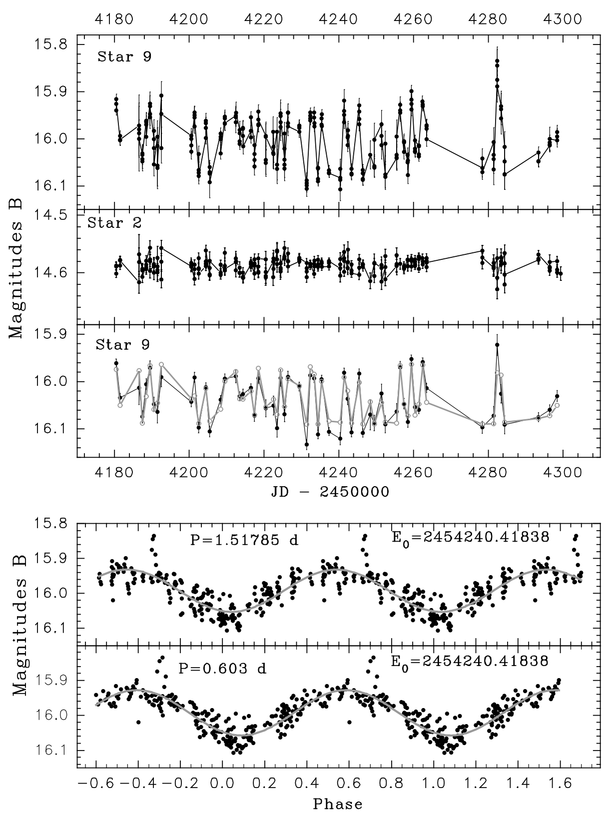

Figure 3. Observed light curves for star 9 and control star 2 as well as phase curves of star 9 in the B band with the period P=1.518 d and P=0.603 d. Nightly average light curves and the points calculated from the sinusoidal model with P=0.603 d (open circles) are shown in the middle of the figure.

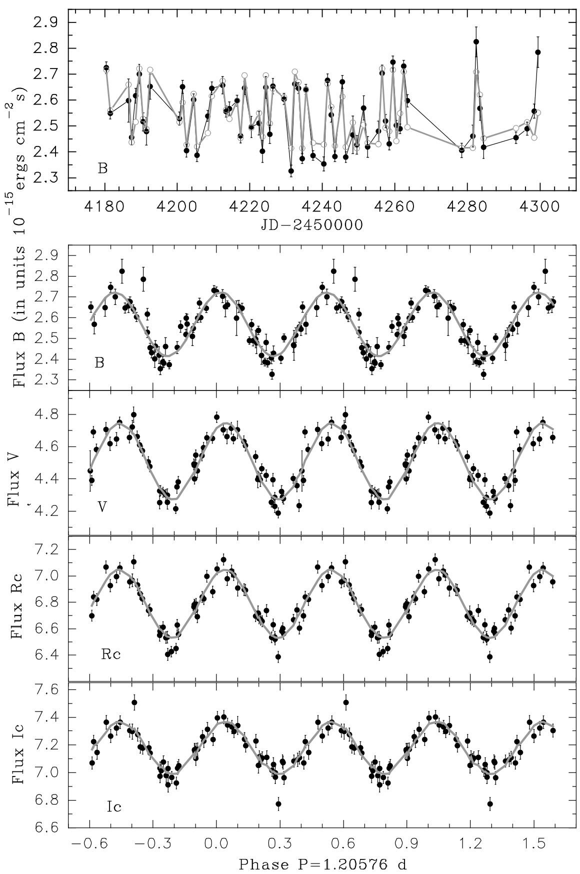

Figure 4. The nightly averaged observed light curve in B band (filled circles) and model fitting (open circles), and phase curves in the $BVRI$ bands folded with the period P=1.205 d. Fluxes is in units 10^{-15} ergs cm^{-2} s-1.

The mean V magnitude and color indices of star 9 are $V = 14\overset{\mathrm{m}}{.}758$, $B - V = 1\overset{\mathrm{m}}{.}245$, $V - R_c = 0\overset{\mathrm{m}}{.}835$, and $V - I_c = 1\overset{\mathrm{m}}{.}637$. The observed $B - V$ color index is normal to the spectral $K5 - K6$ class. The variability amplitude derived from the average phase light curves slightly decreases from B to I: $\Delta B = 0\overset{\mathrm{m}}{.}106$, $\Delta V = 0\overset{\mathrm{m}}{.}098$, $\Delta R_c = 0\overset{\mathrm{m}}{.}078$, and $\Delta I_c = 0\overset{\mathrm{m}}{.}053$. Probably we observed a small blue flare (Fig. 5) with an amplitude of about $0\overset{\mathrm{m}}{.}1$ in B on July 30, 2007. This flare was not seen in the RI filters.

The observed dependence of the color indices on V (Fig. 6) can be comprehended in the framework of cold spots on star 9. When the brightness increases, the $(V - R_c)$ and $(V - I_c)$ color indices decrease. Such relationships were observed, in particular, in the spotted stars LQ Hya (Alekseev & Kozlova, 2002), in the star HBC 379 (Grankin 1998), and in V410 Tau (Petrov et al., 1994), and others. Such color changes are consistent with those seen in some RS CVn stars with spot activity, for example, in IN Com (Alekseev, Kozhevnikova, 2004).

The exact variability type is difficult to determine from only photometric data without reference to spectral data. Nevertheless, we found that this star belongs to the spectral class $K5 - K6$, its brightness varies with a period which is slightly greater than 1 day, the phase light curves are almost sinusoidal, and the variability amplitude is about $0\overset{\mathrm{m}}{.}1$. These results as well as the relationships between V and color indices and the possible presence of flares indicate that star 9 probably belongs to the class of fast-rotating spotted dwarf stars or to close/contact binaries with spot activities (W UMa or RS CVn type systems).

We wish to thank Dr. Katalin Oláh, Dr. Roald Gershberg, Dr. Konstantin Grankin, and the referee for useful discussions. This study was partially supported by the Russian Foundation for Basic Research (Grant No. 06-02-16843).

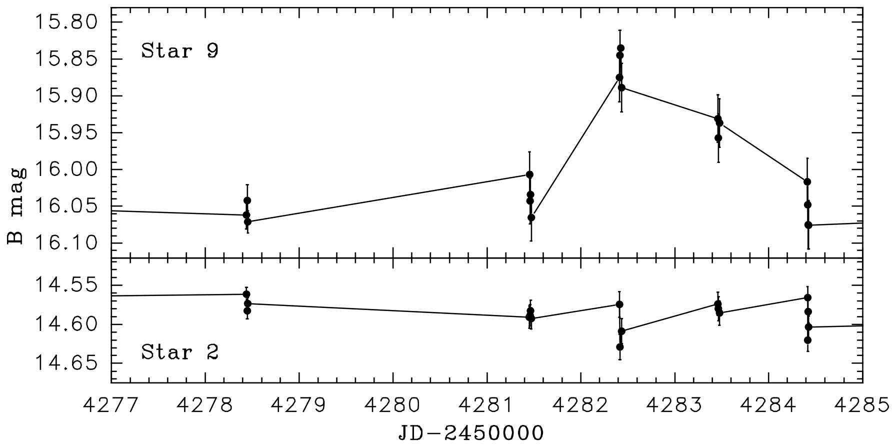

Figure 5. The flare on star 9 in B.

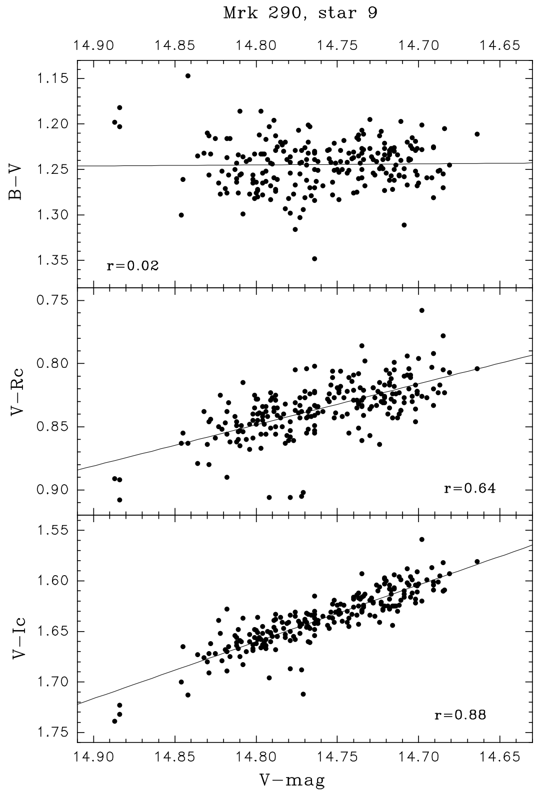

Figure 6. The relationships between the V magnitudes and color indices.

References:

Alekseev, I.Y., Kozhevnikova, A.V., 2004, *Astrophysics*, **47**, 443
Alekseev, I.Yu., Kozlova, O.V., 2002, *Astron. Astrophys.*, **396**, 203
Doroshenko, V.T., Sergeev, S.G., Merkulova, N.I. et al., 2005, *Astrophysics*, **48**, No 2, 156
Grankin, K.N., 1998, *Pis'ma Astron. Zh.*, **24**, 54
Pelt J., 1992, *"Irregularly spaced data analysis - User Manual"*, Helsinki Univ. Press, Helsinki
Petrov, P.P., Shcherbakov, V.A. et al., 1994, *Astron. Astrophys. Suppl. Ser.*, **107**, 9
Schlegel, D.J., Finkbeiner, D.P., Davis, M., 1998, *Astrophys. J.*, **500**, 525
Zacharias, N., Monet, D.G., Levine, S.E. et al., 2004, *American Astron. Soc. meeting*, **205**, 48, 15

ERRATA FOR IBVS 5438, 5543, 5713

As Dr. Samus reported, the star erroneously labelled GSC 02850-01075 is really GSC 00285-01075.

The Editors