NEW SX Phe VARIABLES IN THE INNERMOST REGION OF M15

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Only one of more than 150 known variables in the globular cluster M15 (Clement et al., 2001) is SX Phe star discovered by Jeon et al. (2001) at $r \approx 5'$ from the cluster's center. Recently, we (Zheleznyak & Kravtsov, 2003) have been successful in finding 28 new variables, among 83 stars with variability detected, in the central part of M15. Two of them we have classified as SX Phe stars. In accordance with their ordinal numbers in our list of the detected variables, they have been denoted as ZK62 and ZK68. Here we present basic observational properties of these stars.
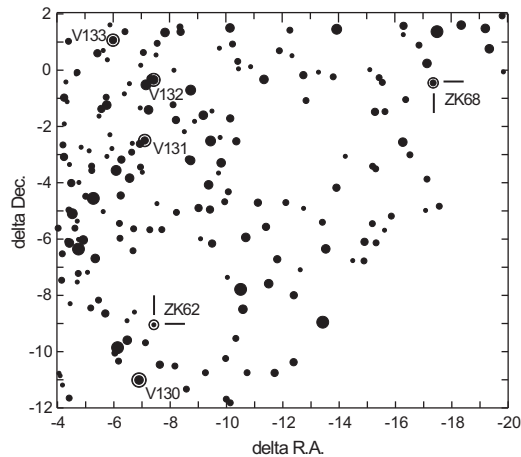
Figure 1. Identification chart for the two newly discovered SX Phe stars in the innermost part of M15, based on the data of van der Marel et al. (2002); four known variables are marked additionally for convenience of identification.

M15 was monitored with the 1.5 m AZT–22 telescope of the Maidanak observatory (Mt. Maidanak, Republic of Uzbekistan), during two sets on successive nights in 2001 July 31 and August 1. The upper culmination of the cluster fell on the middle of the time interval, equal approximately to 3 hr, of each set. More than two hundred cluster images were obtained under photometric conditions, in the R passband close to the standard Cousins' one, with angular resolution (FWHM) typically falling between $0''\!\!.5 - 0''\!\!.9$.

Table 1. Basic data on the newly discovered SX Phe stars in M15

$Name^{a}$	ID_{vdM}^{b}	α_{2000}	δ_{2000}	Period	Epoch of max.	ΔR
ZK62	10041	$21^{h}29^{m}57{\overset{s}{.}}76$	$+12°09'54{\overset{''}{.}}20$	$0{\overset{d}{.}}052$	2452122.0239	$0{\overset{m}{.}}25$
ZK68	10344	$21^{h}29^{m}57{\overset{s}{.}}05$	$+12°10'03{\overset{''}{.}}10$	$0{\overset{d}{.}}076$	2452121.9916	$0{\overset{m}{.}}20$

[a] According to notations in our list from Zheleznyak & Kravtsov (2003)
[b] Identification numbers in catalog of HST photometry in M15 by van der Marel et al. (2002)

Average resolution on the frames has been estimated to be $0{\overset{''}{.}}74$. The observations have been performed with 765×510 ST7 CCD camera attached to the telescope in its Ritchey–Chretien short ($f/7.7$) focus with the focal plane scale giving $0{\overset{''}{.}}15 \times 0{\overset{''}{.}}15$ per CCD pixel size of 9×9 μm. The cluster images were taken with exposure of 1 minute per frame, at a rate ~ 40 frames per hour.

Reduction of the raw CCD data included standard procedures, namely bias subtraction, dark subtraction, flatfielding operations using twilight sky exposures, and removing of cosmic rays. Also, the observational data were corrected for the effect of nonlinearity of the CCD camera.

Image processing was carried out with specially developed software based on idea of optimal image subtraction method proposed by Alard & Lupton (1998).

The positions, $\Delta\alpha''$ and $\Delta\delta''$, of the variables relative to the object AC 211 (identified with the X-ray source X2127+119 by Aurière et al. (1984)) were determined in equinox 2000 coordinates. We transformed the variables' pixel coordinates to the RA and DEC offsets relative to AC 211, using the respective coordinate data for reference stars from catalog by Yanny et al. (1994). The offsets ($\Delta\alpha''$, $\Delta\delta''$) of ZK62 and ZK68 have been determined to be $(-7{\overset{''}{.}}39, -8{\overset{''}{.}}70)$ and $(-17{\overset{''}{.}}70, 0{\overset{''}{.}}20)$, respectively. Equatorial coordinates, α and δ, of the variables have been calculated from the offsets by accepting for AC 211 $\alpha_{2000} = 21^{h}29^{m}58{\overset{s}{.}}26$ and $\delta_{2000} = +12°10'02{\overset{''}{.}}90$ from the above paper by Yanny et al. (1994). The coordinates along with other basic data on the newly discovered SX Phe variables in M15 are given in Table 1.

We have been successful in identifying ZK62 and ZK68, within the accuracy $\sim 0{\overset{''}{.}}1 - 0{\overset{''}{.}}2$ on each coordinate, with stars from the recently published catalog of HST photometry in M15 by van der Marel et al. (2002), what is shown in the identification chart presented in Figure 1. According to photometric data from the same catalog, these stars are located in the cluster color-magnitude diagram about 2 mag. below the horizontal branch, between the subgiant branch and the extended blue horizontal branch. Thus, the stars very likely belong to blue stragglers. Other line of evidence that ZK62 and ZK68 are of SX Phe type of variables is the characteristics of their variability.

Figure 2 shows the observed light curves of ZK62 and ZK68, and Figure 3 demonstrates their phased light curves for the most probable periods of their variability. For convenience of representation, the light curves have arbitrarily been shifted along the ordinate axis, i.e. along the relative magnitude ΔR.

Periods and epochs of maximum of the variables under study have been determined by applying time series analysis package implemented in the MIDAS system. Since our observations cover a relatively limited time interval, values of the periods determined are accurate within several thousandths of a day. However, both the observed light curves and time series analysis show that the periods of ZK62 and ZK68 are consistent with typical periods of SX Phe variables.
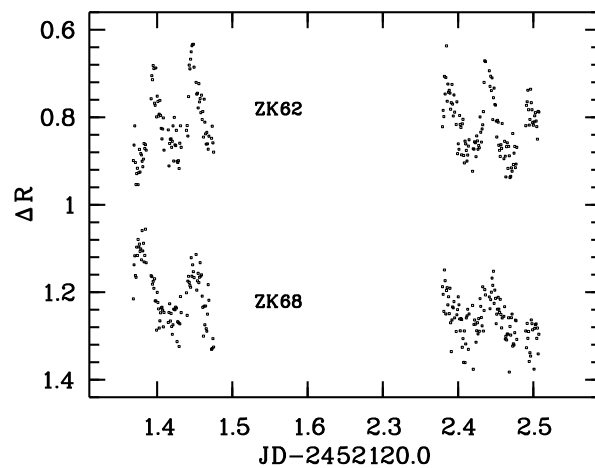
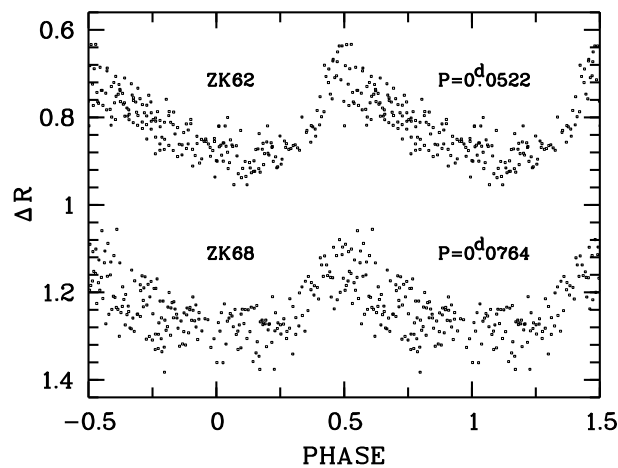**Figure 2.** Observed light curves of the variables ZK62 and ZK68 in the R passband.

Figure 3. Phased light curves of the variables ZK62 and ZK68 in the R passband.

References:

Alard, C., & Lupton, R. H., 1998, *ApJ*, **503**, 325

Aurière, M., Le Fèvre, O., & Terzan, A., 1984, *A&A*, **138**, 415

Clement, C. M., Muzzin, A., Dufton, Q., et al., 2001, *AJ*, **122**, 2587

Jeon, Y.-B., Kim, S.-L., Lee, H., & Lee, M.G., 2001, *AJ*, **121**, 2769

van der Marel, R. P., Gerssen, J., Guhathakurta, P., Peterson, R. C., & Gebhardt, K., 2002, *AJ*, **124**, 3255

Yanny, B., Guhathakurta, P., Bahcall, J. N., & Schneider, D. P., 1994, *AJ*, **107**, 1745

Zheleznyak, A. P., & Kravtsov, V. V. 2003, *AstL*, **29**, 599