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TWO NEW BLAZHKO STARS: XZ UMi AND VX Scl

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1 Introduction

Amplitude and phase modulation of the light curves of pulsating stars is quite common. In RR Lyrae stars pulsating in the fundamental mode almost every other star is considered to show some kind of modulation (Jurcsik et al. 2009; Benkő et al. 2010). The nature of this phenomenon, called the Blazhko effect (Blažko 1907), and its observed characteristics are still poorly understood (see e.g. Kovács 2009, 2015, and Szabó 2014). Also the reasons why some of the stars are modulated, and some not, are not clear (e.g. Skarka 2014b).

We give a brief note about a discovery of modulation in two RRab stars XZ UMi and VX Scl. The targets were observed as a part of the Czech RR Lyrae Observational Project (Skarka et al. 2013; Skarka et al. 2015). In both stars we observed scattering around maximum light which is typical of Blazhko stars. Because our data were insufficient for reliable confirmation of the Blazhko effect and determination of the modulation period, publicly available data from sky surveys archives were utilized.

2 XZ UMi

Variability of XZ UMi was firstly noted by Wils et al. (2006) in NSVS data (Wozniak et al. 2004, 148 data points, time span of one year). We observed this star in seven nights from December 2014 to April 2015 at Masaryk University Observatory (MUO), Brno, Czech Republic, with a 24inch Newtonian telescope equipped with MII G2-4000 camera. We obtained about 450 data points in Johnson-Cousins BVR_cI_c filters. For the sake of clarity we give only data for B-filter, because the modulation is most apparent in this filter. Identification of comparison stars can be found in Table 1 and in the left panel of Fig. 1.

Table 1: Cross-identification of XZ UMi and comparison stars. Coordinates and magnitudes come from the UCAC4 (APASS photometry) catalogue (Zacharias et al. 2013).

ID UCAC4	RA(2000)	DEC(2000)	V [mag]	$B-V$ [mag]
XZ UMi				
824-016693	14 39 51.623	+74 45 02.08	11.884	0.732
comp star				
824-016709	14 41 10.264	+74 36 29.03	11.772	0.895
check star				
824-016696	14 40 18.613	+74 40 37.14	12.032	1.055

From the top panel of Fig. 2 it is apparent that XZ UMi is a Blazhko star with very distinct amplitude modulation. From our measurements we estimate the pulsation period as 0.58521(2) d (we used Period04 software, Lenz & Breger 2005). This value is slightly different from the NSVS-based pulsation period (0.58506(2) d). Although both values are determined on the basis of not optimal data samples, the difference of $1.5{\cdot}10^{-4}$ d could indicate period change.

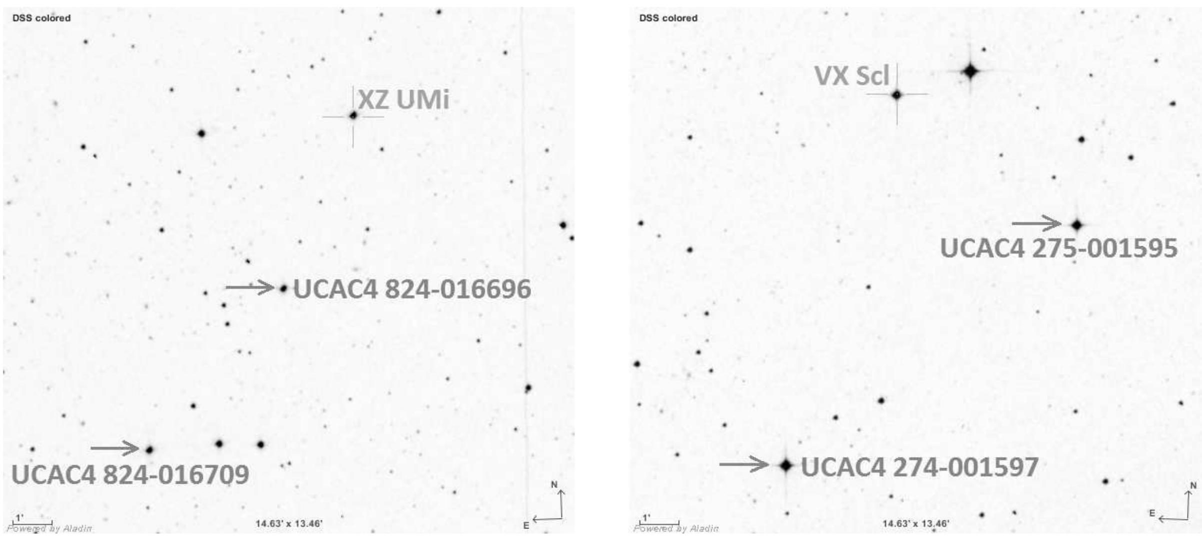

Figure 1. Identification of stars used as comparison and check stars.

Our data are insufficient for the determination of modulation period, but in the NSVS survey data a side peak just next to the basic pulsation frequency was identified after removing the only two detectable pulsation components (Fig. 3, top panel). The separation between the basic pulsation peak (in this figure highlighted by the dashed line) and the side peak is 0.0243(1) c/d. Blazhko period is then 41.1(2) d. The detected frequencies in NSVS data set are in Table 2.

3 VX Scl

This star was suspected of modulation by Skarka (2014a). We observed it in 9 nights (2014 - 2015) using FRAM (F(/Ph)otometric Robotic Atmospheric Monitor, Ebr et al.

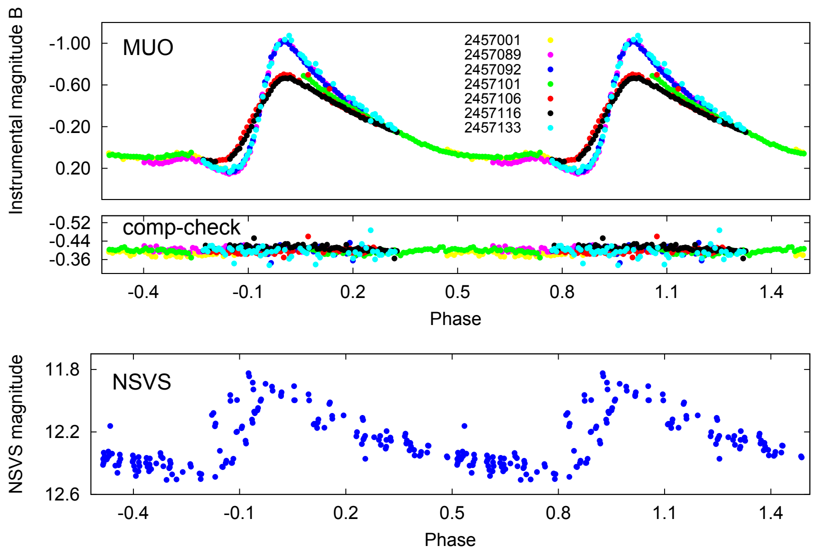

Figure 2. XZ UMi data phased with period of 0.58521(2) d and zero epoch 2457092.4632(9).

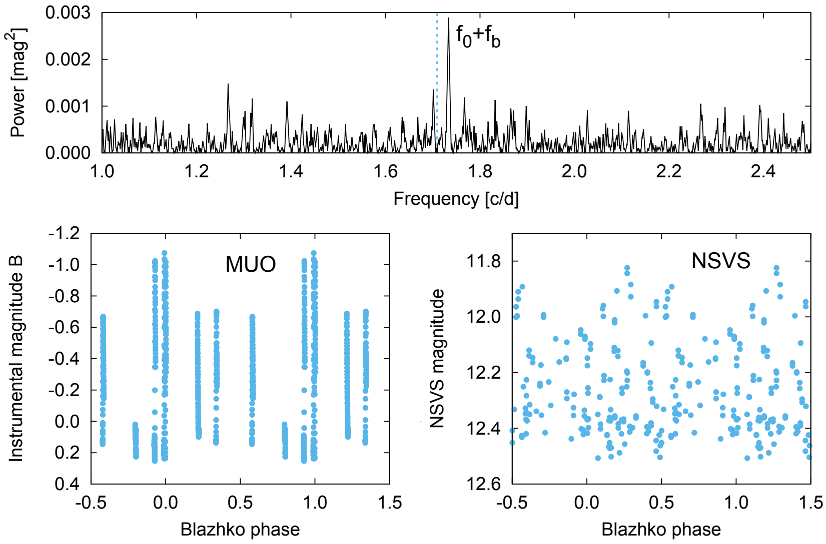

Figure 3. The top panel shows NSVS frequency spectra of XZ UMi after extraction of detectable pulsation components (f_0 and $2f_0$), while the bottom panels show the data phased with the Blazhko period. The location of the basic pulsation frequency f_0 is marked by the dashed line in the top panel.

Table 2: Frequencies detected in the NSVS data of XZ UMi.

ID	f [c/d]	A [mag]	ϕ [rad]
f_0	1.70915(5)	0.196(7)	2.06(5)
$f_0 + f_\mathrm{b}$	1.7334(2)	0.062(7)	0.36(11)
$2f_0$	3.4185(1)	0.086(7)	4.92(2)

Table 3: VX Scl and comparison stars.

ID UCAC4	RA(2000)	DEC(2000)	V [mag]	$B-V$ [mag]
VX Scl				
275-001600	01 35 23.658	−35 07 42.57	11.928	0.311
comp star				
275-001595	01 35 01.127	−35 11 01.03	11.587	0.470
check star				
274-001597	01 35 37.542	−35 17 10.53	11.021	0.565

2014) - a 300/3000 mm Schmidt-Cassegrain telescope placed near Malargüe at the Pierre Auger Observatory, Argentina. This telescope is equipped with MII G2-1600 camera with *BVRI* filters. We obtained more than 300 data points in each of the filters, but we show only data in *V*-filter because in this filter we got the largest number of measurements around maxima.

The scatter around maximum light suggests modulation (Fig. 4). However, our data were insufficient to certainly decide about the Blazhko effect and for determination of the modulation period. Fortunately, VX Scl was observed by the SuperWASP survey in 2006 and 2007 (Pollacco et al. 2006).

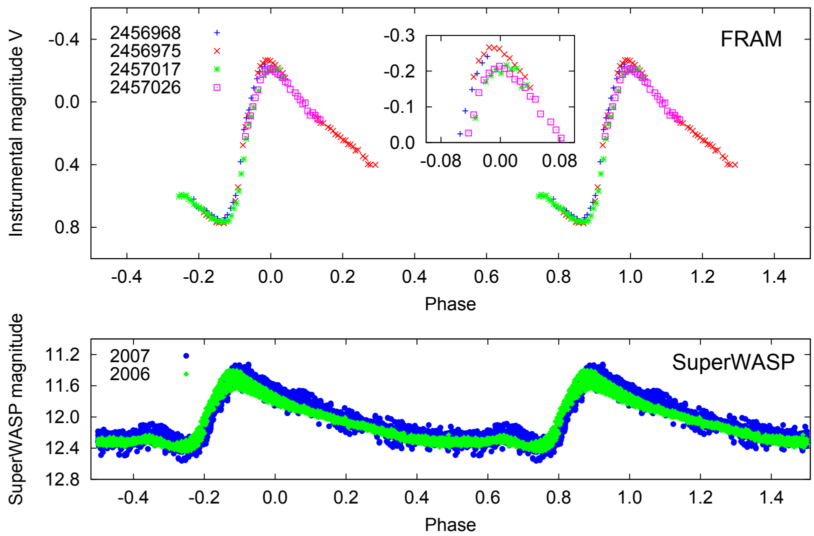

Figure 4. VX Scl data phased with the basic pulsation period of $1/f_0 = 0.637061(1)$ d and zero epoch 2456975.6521(5). Only data from four nights are shown in the top panel for better clarity.

Skarka (2014a) did not analyse SuperWASP data because they did not fulfil high demands for his analysis. We removed all data points with the uncertainty higher than 0.02 mag. Only data from camera 221 were used for frequency analysis (7712 points, time span of two years). After removing detectable pulsation components ($kf_0 = k \cdot 1.569708(2)$ c/d, where $k = \langle 1, 7 \rangle$) side peaks near f_0, $2f_0$[1] were revealed (see the top panel of Fig. 5 where the frequency spectrum around f_0 is shown). The spacing is 0.01486(4) c/d which is equivalent to modulation period of 67.3(2) d. SuperWASP data phased with the modulation period are shown in the bottom panel of Fig. 5. The modulation envelope

[1]When analysing seasons separately, in the first part of the data also $3f_0 + f_\mathrm{b}$ was detected.

created from maximum magnitudes with amplitude of about 0.15 mag is well apparent.

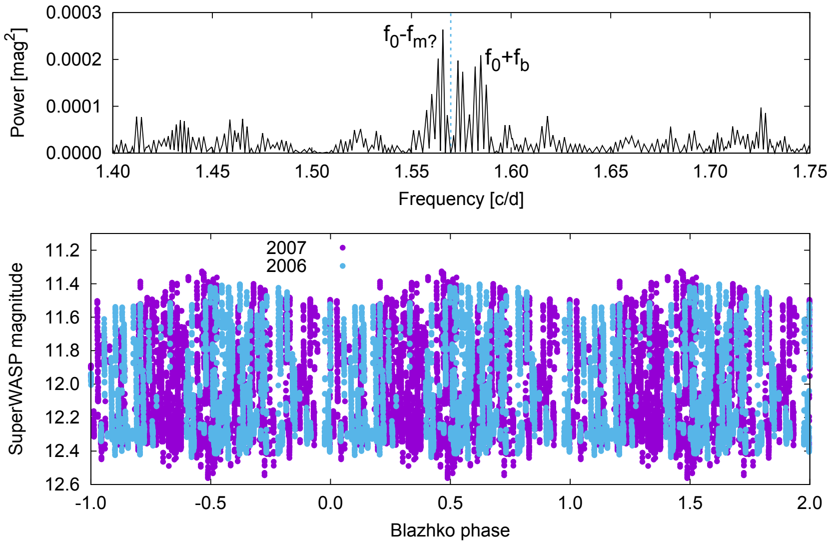

Figure 5. Frequency spectrum of VX Scl based on SuperWASP data after subtraction of seven detectable main pulsation components with position of f_0 highlighted by the dashed line (top panel). The bottom panel shows SuperWASP data phased with the modulation period of 67.3 d.

The full light-curve solution for SuperWASP data is given in Table 4. Beside these peaks, additional peaks appeared near 0.001, 4, 5, and 7 c/d when both seasons were analysed together. The peaks were not detected in the first part of the data. Therefore we suspect them from the artificial nature arising from the shifts between seasons and nights in the second part of the data (see the bottom part of Fig. 4 from where it is apparent that the data from season 2007 have significantly larger scatter than from the season 2006).

The basic pulsation period of VX Scl is probably slowly changing which could be deduced from the bottom panel of Fig. 4 where data from both seasons are shifted in phase. In addition, bunch of peaks close to f_0 supports this hypothesis. Alternatively, we cannot exclude that VX Scl could be multi-modulated Blazhko star – the closest nearly-equidistant peaks to f_0 indicate the modulation period of about 274 d[2] (peak marked as $f_0 - f_{m?}$ in Table 4). However, for more reliable analysis larger data sets would be needed, because the separation of the peaks from f_0 is only twice the Rayleigh criterion.

4 Conclusions

Presented analysis showed that RRab stars XZ UMi and VX Scl are modulated with periods of 41.1 d and 67.3 d, respectively. The attention to these targets was brought on the basis of our original measurements. The results for both stars should be considered as preliminary estimates because both targets probably show more complex behaviour. From our figures it is apparent that the pulsation period of both stars could be variable. In VX Scl we have a suspicion of either double modulation with additional Blazhko component with a period of about 274 d, or of secular period change apparent in SuperWASP data. In both targets better data sets are needed for more reliable analysis.

[2]No corresponding peaks were detectable near kf_0.

Table 4: Frequencies identified in the SuperWASP data of VX Scl.

ID	f [c/d]	A [mag]	ϕ [rad]
f_0	1.569708(2)	0.3148(11)	4.758(1)
$f_0 - f_{m?}$	1.56606(3)	0.0246(10)	2.55(1)
$f_0 + f_b$	1.58457(4)	0.0161(9)	1.56(2)
$2f_0$	3.139315(5)	0.1381(8)	6.001(1)
$2f_0 + f_b$	3.15401(7)	0.0093(8)	1.17(2)
$3f_0$	4.709001(5)	0.1074(8)	2.412(1)
$4f_0$	6.278645(8)	0.0742(8)	3.462(2)
$5f_0$	7.84835(1)	0.0489(8)	0.674(2)
$6f_0$	9.41799(3)	0.0239(8)	1.182(7)
$7f_0$	10.98767(6)	0.0113(8)	5.57(1)

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