MIRAS OR SRA'S – THE TRANSIENT TYPE VARIABLES

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ABSTRACT. The variability of several stars shows "Mira-type" and "semiregular" behavior during long-time data ranges. Such data are available due to amateur visual observations from AAVSO and AFOEV databases. We have studied these properties by using different methods of time-series analysis, such as the periodogram analysis using trigonometric polynomial fit, wavelet analysis and individual cycle characteristics analysis using the running parabola fit. As the result, very similar multiperiodicities were detected.

Key words: Stars: LPVs, Mira-type, semiregular, individual: S Aql, S Tri, Y Per.

Three variables: S Aql, S Tri, Y Per drew our attention due to similar properties of their photometric behavior: intervals of periodical (Mira-type) variability with relatively high amplitudes turns to "semi-regular" (SR-type) small-amplitude oscillations with not so prominent periodicity on their light curves (Fig. 4, see also Fig 5 in Marsakova (1999)). Such transitions were mentioned also in R Dor (Bedding et al., 1998). Another similarity is their main and secondary periods that are close too. The fourth star RU And with similar periods was analyzed by (Chinarova, 2010) so we also refer to it here.

We have analyzed light curves of these stars obtained by amateur astronomers from the AFOEV and AAVSO databases of visual observations, which cover the interval J.D. 2418000–2455600 (only for S Tri the interval is shorter - since J.D. 2439000).

Traditional classification in the "General Catalogue of Variable Stars" (GCVS, Kholopov et al, 1985; Samus' et al., 2012) separates Miras from SR's is related with the 2^m level of visual amplitude. Thus in the Table 1 we represent main characteristics of these variables from the GCVS as well as our own results – the values of the mean periods and amplitudes calculated using trigonometric polynomial fit (Andronov, 1994) and the amplitudes determined by fitting individual cycles using the method of "running parabola" (Andronov, 1997). A review on long-period variables was presented by Kudashkina (2003).

One may see that during individual cycles, the amplitude reaches Mira-like values, but not all the time.

1. Periodogram analysis. Multiperiodicity.

The periodogram analysis was made using the program MCV described by Andronov and Baklanov (2004).

S Aql. Kiss et al. (1999) have analyzed the variability of this star, but haven't found multiperiodicity. The periods of it were also discussed by Chinarova and Andronov (2000). We have obtained very similar values: P_1=146.7^d, P_2=245.2^d, P_3=104.6^d, P_4=746.3^d (See Fig. 1). But one may see that, in the "semiregular" interval J.D. 2449800–2453800, the main peak at the periodogram became relatively smaller and appears peak of 133.2^d instead 104.6^d that come very small.

S Tri. In the case of this star we deal with smaller time range and the percentage of the "semiregular" variability is higher. From the periodogram (Fig. 2), we have obtained periods P_1=249.5^d, P_2=148.1^d, P_3=129.1^d, P_4=792.6^d.

Y Per. Kiss et al. (1999) have found changes from mono-periodicity with P=253^d to bi-periodicity with P_1=245^d, P_2=127^d. Our Fig. 3. shows peaks at both P=253^d and P=245.3^d in whole interval followed by small peaks P_2=149.4^d, P_4=768.9^d, and more clear P_1=247.3, P_2=776.4^d, P_3=147.6^d, P_4=129.0^d in the "semiregular" interval J.D. 2447000–2453800.

Two periods (147.6 (4 harmonics), 247.3 (2 harmonics)) trigonometric polynomial fit of "semiregular" interval S Aql is shown at Fig. 5.

Three periods (247.3, 129, 147.6,) trigonometric polynomial fit of "semiregular" interval Y Per is shown at Fig. 6.

RU And – the variability analysis was discussed by Chinarova (2010). The wavelet analysis was made there and periods P_1=247^d, P_2=260^d, P_3=125.1^d, P_4=735.8^d have been detected. It was also pointed that the semi-amplitude of RU And varies drastically from 0.027^m ("nearly constant star") to 1.204^m ("Mira"- type pulsating variable).

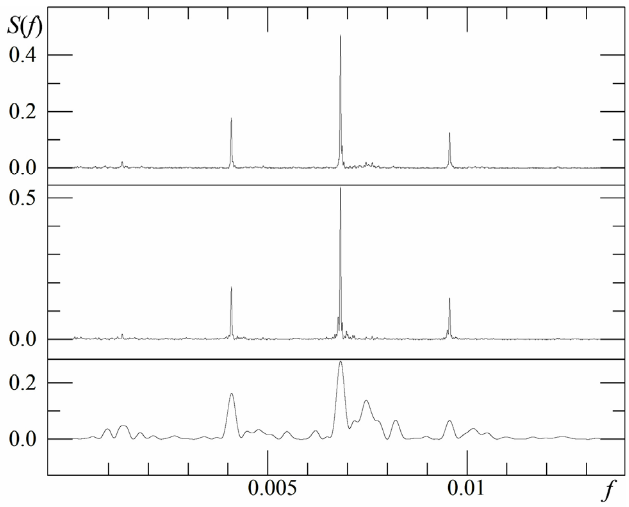

Fig. 1. Periodograms for S Aql (from up to bottom: whole interval, interval without J.D. 2449900–2453800, interval J.D. 2449800–2453800)

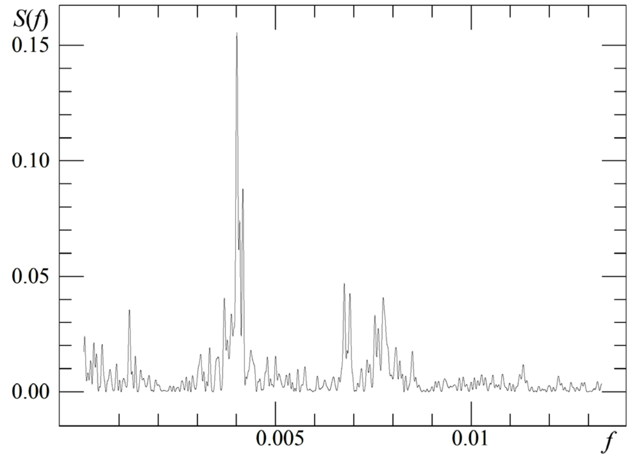

Fig. 2. Periodogram for S Tri

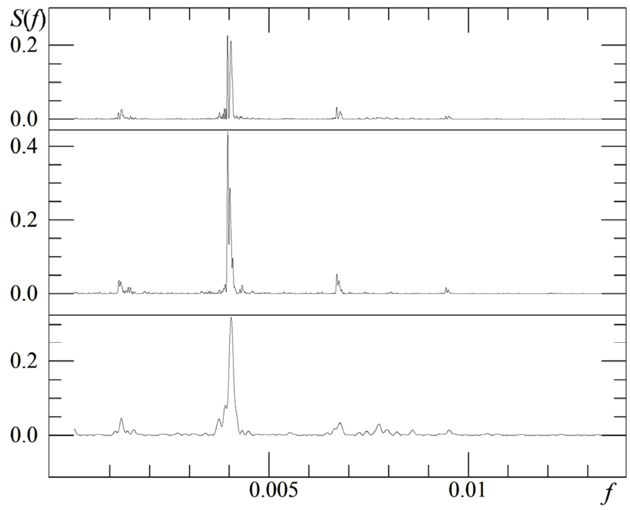

Fig. 3. Periodograms for Y Per (from up to bottom: whole interval, interval without J.D. 2447000–2455800, interval J.D. 2447000–2455800)

It's remarkable, that the periods 245–250^d are represented by all these stars and the periods 145–150^d and 125–130^d we meet very often. The period of about 750^d may be interpreted as 3×250^d or 5×150^d. 125^d is a half of 250^d and may be a harmonic of the main period. But what is the sense of 245–250^d and 145–150^d periods and its ratio (near 1.7)? Is this evidence of close evolutionary stages? Is this stage long-lasting, if we observe many variables with these periods?

2. Wavelet analysis

The wavelet analysis was performed using the program WWZ (Andronov, 1998). Using the wavelet analysis, we have determined best fit values of the period as a function of trial time. The corresponding plots are shown in Fig. 4.

It seems that Y Per has more stable period than other two variables. Before the date J.D. 2447000, it looks like a typical carbon Mira-type variable (Marsakova, 1999). Long periodicity, which sometimes appears in S Tri, may be caused by a small amount of data points in these time intervals.

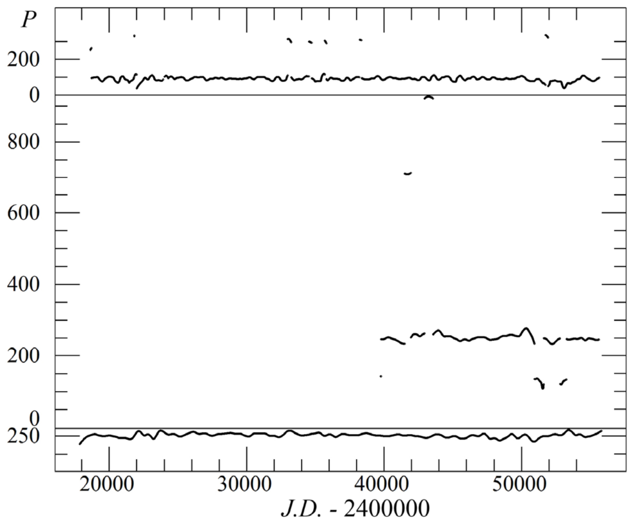

Fig. 4. The best fit values of the period as function of trial time determined using wavelet analysis

3. Individual cycle variability analysis

Classification criteria based on individual cycle variability of Miras were discussed by Marsakova and Andronov, 2006). Let's compare Fig. 2, 5, 7 there with our Table 2. (Where ΔAm, $\Delta T_{мин}$, ΔM are the ranges of individual amplitudes, times between successive minima and mean brightness in the sense of (Marsakova & Andronov, 2006). The denominators are mean values (see Table 1)). According to Marsakova and Andronov (2006), typical Miras lie under values 1.5, 0.3, 1, respectively. One may see that one or several parameters are not in the Miras' range.

Table 2. Individual cycle variability parameters.

Star	$\Delta Am/\langle Am\rangle$	$\Delta T_{min}/\langle P\rangle$	$\Delta M/\langle Am\rangle$
S Aql	1.6	0.8	0.8
S Tri	3.2	0.8	2.3
Y Per	1.2	0.6	0.4

Table 1: Some mean characteristics of the variables

Star	GCVS			Our calculations			
	Type	Sp.	*P*	*P*	***AM***	$\boldsymbol{AM}_{max}$	$\boldsymbol{AM}_{min}$
S Aql	SRa	M3e–M5,5e	146.45^d	146.6^d	1.82^m	3.04^m	0.12^m
S Tri	M	M2e	241.6^d	249.3^d	0.52^m	2.06^m	0.35^m
Y Per	M	C4,3e	248^d	252.69^d	1.55^m	2.20^m	0.41^m

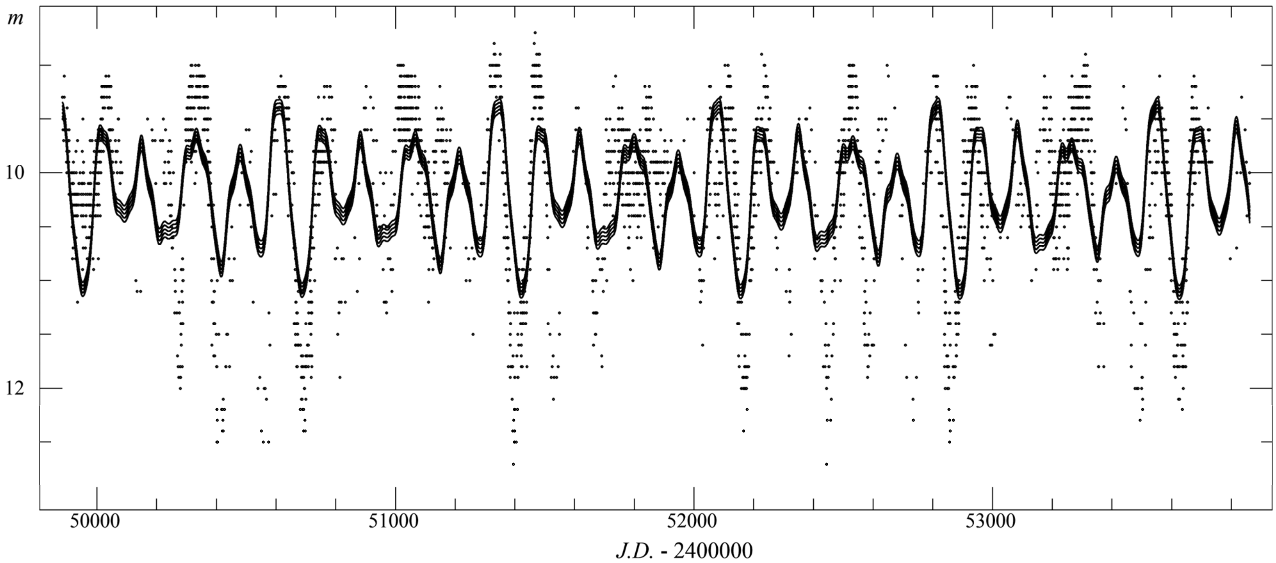

Fig.5. Variability of S Aql: with trigonometric polynomial fit (with two periods 146.7^d (4 harmonics), 245.2^d (2 harmonics)) in the interval J.D. 2449900–2453800.

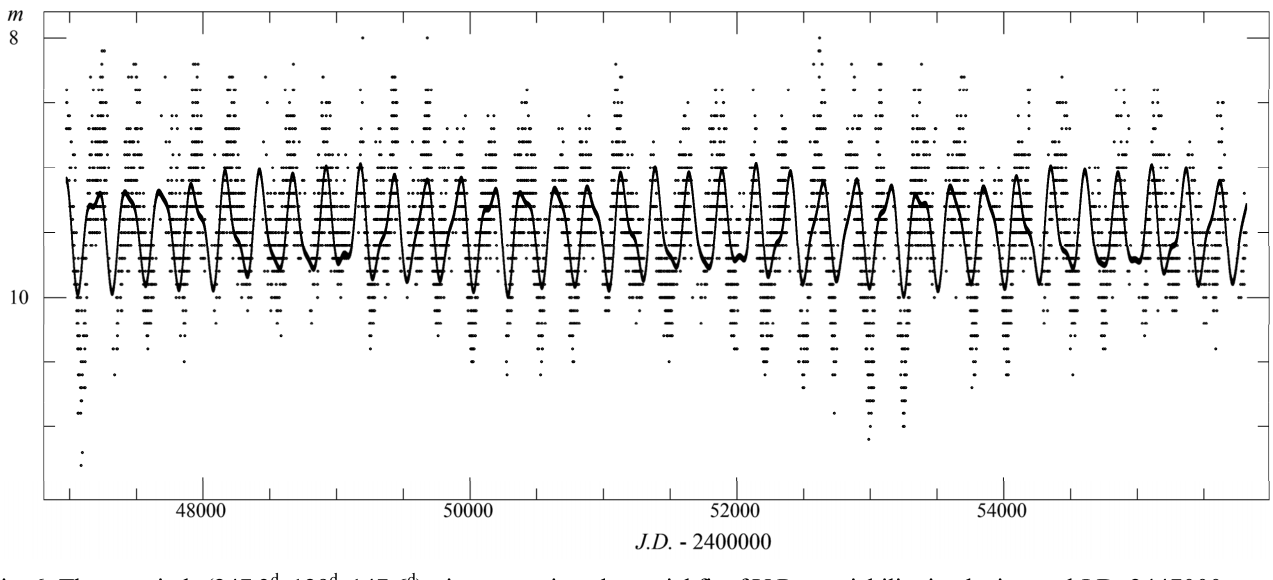

Fig. 6. Three periods (247.3^d, 129^d, 147.6^d) trigonometric polynomial fit of Y Per variability in the interval J.D. 2447000–2453800.

The amplitude and mean brightness changes are shown in Fig. 7 for a sample star Y Per.

So these variables may be classified as “Miras” only in short time intervals. Generally such classification is unacceptable for them. But among SRa’s, they may form the separate group of “transient” variables.

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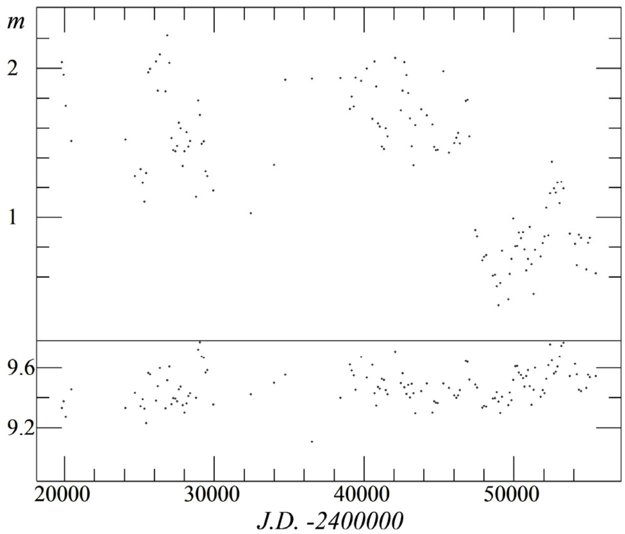

Fig. 7. Y Per: amplitudes and mean brightness for ascending and descending branches of each individual cycle.

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References

Andronov I.L.: 1994, *Odessa Astron. Publ.*, **7**, 49

Andronov I.L.: 1997, *Astron. Astrophys. Suppl.*, **125**,207

Andronov I.L.: 1998, *Kinem. Phys. Celest.Bodies*, **14**, 490

Andronov I.L., Baklanov A.V.: 2004, *Astronomy School Reports*, **5**, 264, *http://uavso.pochta.ru/mcv*

Andronov I.L., Chinarova L.L.: 2001, *Odessa Astron. Publ*, **13**, 113

Bedding T.R., Zijlstra A.A., Jones A., Foster G.: 1998, *Mon. Not. Roy. Astr. Soc.,* **301**, 1073

Chinarova L.L.: 2010, *Odessa Astron. Publ*, **23**, 25

Chinarova L.L., Andronov I.L.: 2000, *Odessa Astron. Publ*, **13,** 116

Kiss L.L., Szatmàry K., Cadmus Jr R.R., Mattei J.A.: 1999, *Astron. Astrophys*., **346**, 542

Kholopov P.N. et al: 1985, *General Catalogue of Variable Stars*, 4-th edition. Moscow: Nauka

Kudashkina L.S.: 2003, *Kinem. Phys. Celest. Bodies*, **19**, 193

Marsakova V.I.: 1999, *Odessa Astron. Publ*, **12**, 205

Marsakova V.I., Andronov I.L: 2006, *Astrophysics,* **49**, 506

Samus N.N., Durlevich O.V., Kazarovets E V., Kireeva N.N., Pastukhova E.N., Zharova A.V., et al. *General Catalog of Variable Stars* (GCVS database, Version 2012Jan), http://www.sai.msu.su/gcvs/gcvs/