SOME POINTS OF THE MONITORING OF FLARE STARS USING THE SYNCHRONOUS NETWORK OF REMOTE TELESCOPES

Ya. Romanyuk

Main Astronomical Observatory, NAS of Ukraine
27 Akademika Zabolotnoho Str., 03680 Kyiv, Ukraine
e-mail: romanyuk@mao.kiev.ua

We analyse the efficiency of observational campaigns which were carried out during seven years involving four astropoints in Ukraine, Russia, Greece, and Bulgaria. A possibility of the synchronous monitoring of stellar flares is discussed in this paper.

INTRODUCTION

The Synchronous Network of Remote Telescopes (SNT) [3] started as a coordinated network of telescopes in 1997, when the 50-inch telescope at the Crimean Astrophysical Observatory was equipped with the second High Speed Two Channel Photometer [4]. The SNT activities are supporting by five groups of astronomers which are working at the Crimean Astrophysical Observatory (CrAO, Ukraine), in the International Center for Astronomical, Medical and Ecological Research (Ukraine–Russia), at the Aristoteleon University (Greece), in the Institute of Astronomy of the Bulgarian Academy of Sciences and at the Main Astronomical Observatory of the National Academy of Sciences of Ukraine. They use photometric complexes at the Terskol Observatory (the Northern Caucasus), CrAO, the Stephanion Observatory (Greece), the Belogradchik Observatory, and/or the Rozhen Observatory (Bulgaria). Three sets of photometers are able to synchronize their time clocks to the UTC with an accuracy up to 1 μs using GPS antennas Acutime 2000.

The primary focus of the SNT is the synchronous monitoring of UV Ceti type stars [2] with high speed (about 10–100 ms per count). Hereby, the data obtained synchronously at distant observatories promote the getting new results in the study of flare-related phenomena in stars. In the previous years simultaneous observations of stars EV Lac, AD Leo, BY Dra, YZ Cmi, KR Aur, *etc.* were performed.

The greatest attention was paid to synchronous observations of the flare star EV Lac with the use of two, three, four, and five photometers at four observatories. A short statistic analysis of the results obtained in 1998–2003 is presented below.

OBSERVATIONS AND RESULTS

A complete and detailed review of the first coordinated international observations with the SNT in September 1998 was prepared by Alekseev *et al.* [1]. Five telescopes at four observatories registered 18 flares. Ten of them were observed simultaneously at two observatories, five – at three observatories, and one – at four observatories. Some observations in the IR region as well spectra were obtained too. The whole campaign was carried out during seven nights with the observing time planned as six hours for each night.

In August 1999 observations were carried out at the Terskol Observatory and the Stephanion Observatory. The observing time was planned as four hours for each night. Two telescopes registered 23 flares during 12 nights but there was not flare observed simultaneously at two astrosites because the bad weather conditions.

The total coverage of EV Lac with observations achieved during the international campaigns in 2000–2003 is showed in Tables 1–5. They present our observations for each night using three terms:

- Synchronous time of monitoring at piece of astrosites (ST#S).
- Number of flares registered simultaneously at piece of astrosites (FR#S).
- Rate of synchronous time at piece of astrosites (RST#S).

The international campaign in October 2000 (Table 1) was not enough successful, because it was too cloudy at observational sites during the observational period. The high-speed two-channel photometer of the 50-inch telescope of the Crimean Astrophysical Observatory was in non-operational state, therefore many sets of the data were unassured. Five telescopes at four observatories have registered 21 flares during 10 nights with the planned observing time of six hours per night, but there were only two flares observed simultaneously with two telescopes.

Table 1. Observations of EV Lacertae in October 2000

Date	$ST2S$	$ST3S$	$ST4S$	$FR1S$	$FR2S$	$FR3S$	$FR4S$	$RST2S$	$RST3S$	$RST4S$
21/22.10.2000	0	0	0	1	0	0	0	0	0	0
22/23.10.2000	4^h37^m	1^h33^m	0	2	0	0	0	77%	26%	0
23/24.10.2000	4^h45^m	0	0	0	0	0	0	79%	0	0
24/25.10.2000	5^h45^m	4^h43^m	2^h44^m	4	0	1	0	96%	77%	46%
25/26.10.2000	3^h55^m	0^h37^m	0	1	0	0	0	65%	10%	0
26/27.10.2000	5^h17^m	0	0	6	0	1	0	88%	0	0
27/28.10.2000	3^h00^m	2^h15^m	0	5	0	0	0	50%	38%	0
29/30.10.2000	2^h54^m	1^h19^m	0	2	0	0	0	48%	22%	0
30/31.10.2000	3^h28^m	0	0	0	0	0	0	58%	0	0

Two observational campaigns were organized in 2001: the first one was carried out during 9 nights in September and the second – during 11 nights in October. For the September campaign (Table 2) we had possibilities for the synchronous monitoring from two astrosites during five nights (five hours per night were planned), but only during 2.2 hours of one night it was possible to observe simultaneously from three sites. Three telescopes at three observatories have registered 19 flares, but no flare was observed at least with two telescopes.

Table 2. Observations of EV Lacertae in September 2001

Date	$ST2S$	$ST3S$	$FR1S$	$FR2S$	$FR3S$	$RST2S$	$RST3S$
09/10.09.2001	0	0	0	0	0	0	0
10/11.09.2001	0	0	1	0	0	0	0
11/12.09.2001	0	0	6	0	0	0	0
12/13.09.2001	0^h13^m	0	3	0	0	5%	0
13/14.09.2001	1^h30^m	0	0	0	0	34%	0
14/15.09.2001	3^h57^m	2^h10^m	3	0	0	79%	44%
15/16.09.2001	2^h33^m	0	0	0	0	58%	0
16/17.09.2001	0	0	2	0	0	0	0
17/18.10.2001	3^h01^m	0	4	0	0	64%	0

The weather conditions during the campaign on October 8–18, 2001 (Table 3) were bad at two of three observatories. Only one of four flares was synchronously registered at two astrosites.

Table 3. Observations of EV Lacertae in October 2001

Date	$ST2S$	$ST3S$	$FR1S$	$FR2S$	$FR3S$	$RST2S$	$RST3S$
08/09.10.2001	0	0	0	0	0	0	0
09/10.10.2001	0	0	0	0	0	0	0
10/11.10.2001	2^h07^m	0	0	0	0	0	0
11/12.10.2001	2^h45^m	0	0	0	0	0	0
12/13.10.2001	0	0	0	0	0	0	0
13/14.10.2001	1^h23^m	0	1	0	0	0	0
14/15.10.2001	2^h15^m	0	2	1	0	0	0
15/16.10.2001	20	0	0	0	0	0	0
16/17.10.2001	0	0	0	0	0	0	0
17/18.10.2001	0	0	1	0	0	0	0
18/19.10.2001	0	0	0	0	0	0	0

The 2002 international campaign for the monitoring the red dwarf EV Lac (Table 4) was carried out during 11 nights (five hours per night were planned). Four telescopes at three observatories were involved. They registered 13 flares and three of them were simultaneously observed at two astrosites. The weather conditions were bad in the Crimea and in the Northern Caucasus.

Table 4. Observations of EV Lacertae in October 2002

Date	*ST2S*	*ST3S*	*FR1S*	*FR2S*	*FR3S*	*RST2S*	*RST3S*
01/02.10.2002	0	0	1	0	0	0	0
03/04.10.2002	2^h00^m	0	1	0	0	45%	0
04/05.10.2002	1^h49^m	0	2	0	0	39%	0
05/06.10.2002	0	0	0	0	0	0	0
08/09.10.2002	2^h16^m	0	2	0	0	45%	0
09/10.10.2002	3^h35^m	1^h05^m	1	1	0	66%	20%
10/11.10.2002	3^h42^m	0	3	2	0	100%	0
11/12.10.2002	0	0	3	0	0	0	0

The last international campaign for the monitoring EV Lac was carried out from September 23 to October 4, 2003 (Table 5). The planned time for monitoring was 4 hours per night. In spite of the inability of the 2-m telescope of the Terskol Observatory, it was the most successful period for the synchronous observations the target star from two observatories. Four telescopes at three observatories registered 26 flares. 13 of them were synchronously observed at the Crimean Astrophysical Observatory and the Stephanion Observatory and one was registered with all four telescopes.

Table 5. Observations of EV Lacertae in October 2003

Date	*ST2S*	*ST3S*	*FR1S*	*FR2S*	*FR3S*	*RST2S*	*RST3S*
23/24.09.2003	3^h11^m	2^h49^m	0	0	0	80%	70%
24/25.09.2003	3^h47^m	0	4	3	0	86%	0
25/26.09.2003	4^h10^m	0	1	1	0	81%	0
26/27.09.2003	0^h30^m	0	3	0	0	12%	0
27/28.09.2003	2^h32^m	2^h27^m	2	1	1	70%	68%
28/29.09.2003	1^h48^m	0	5	2	0	42%	0
29/30.09.2003	0	0	3	0	0	0	0
30/01.10.2003	4^h15^m	0	3	2	0	99%	0
01/02.10.2003	3^h21^m	0	2	0	0	80%	0
02/03.10.2003	3^h52^m	0	3	2	0	74%	0
03/04.10.2003	0	0	0	0	0	0	0

CONCLUSIONS

The observations statistics of the five international campaigns carried out in 2000–2003 are presented in Tables 1–5. At least three of four observatories from Russia (Terskol), Ukraine (CrAO), Greece (Stephanion), and Bulgaria (Rozhen or Belogradchik) were involved in each campaign. In the monitoring campaign 2000 all four observatories with five telescopes have participated, in campaigns in 2001–2003 – three observatories. 241 hours during 53 nights were planned for synchronous observations during all campaigns. We obtained 97 (40%) hours of synchronous observations at two astrosites and about 19 hours – at three astrosites. 20 flares were synchronously registered with photometers at two sites and only one – with photometers at three sites. We have not any minute of synchronous observations at four sites during possible 60 hours (10 nights) in 2000. The good common statistics for the data obtained simultaneously at two astropoints do not satisfy us.

There are some reasons of the non-coincidence of observational tine intervals periods at the participated observatories. The main one is a weather factor, the next – operational integrity and possibility to get observational time on fixed dates on the telescopes. Sometime distant telescopes use different time intervals to measure the sky background or reference stars for the same observational set. This makes impossible to register some flares simultaneously at least with two photometers.

We hope this information will be useful for astronomers who plan synchronous observations of such rare phenomena as flares on UV Ceti stars [2] or similar.

Acknowledgements. I am grateful to B. Zhilyaev, I. Verlyuk, J. Seiradakis, S. Avgoloupis, M. Contadakis, R. Konstantinova-Antova, and A. Antov for the help in the collection of all obtained observational data, and to V. Godunova for her useful remarks.

Observations of the Kyiv team at the Crimean Astrophysical Observatory and at the Terskol Observatory during 2000–2003 were mostly supported by grants of the Ministry of the Education and Science of Ukraine 2M/146–2000 and 2M/86–2001.

[1] *Alekseev I. Yu., Antov A. P., Avgoloupis S. J., et al.* Coordinated observations of the red dwarf flare star EV Lac in 1998 // Kinematics and Physics of Celestial Bodies.–2001.–**17**, N 2.–P. 147–156.

[2] *Gershberg R. E.* The solar-type activity amongst the main sequence stars.–Odessa: Astroprint, 2002.–688 p.

[3] *Romanyuk Ya., Zhilyaev B., Svyatogorov O., et al.* The synchronous network of optical telescopes: a new instrument for stellar photometry // Proc. of 5th Conf. of the Hellenic Astron. Soc. Crete, Sept. 20–22, 2001. [`http://www.astro.auth.gr/~helasmtg/2001`].

[4] *Zhilyaev B. E., Romanyuk Ya. O., Svyatogorov O. A.* The high-speed automatic two-channel photometer // Astron. Zh.–1992.–**69**, N 4.–P. 895–900.