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The investigation of Nova M31 2005–13 with small telescopes.

N. Katysheva[1], A. Zharova[1] and S. Shugarov[1,2]

[1] *Sternberg Astronomical Institute, Moscow State University, 119991, Universitetskij pr., 13, Moscow, Russia, (E-mail: natkat2006@mail.ru)*

[2] *Astronomical Institute of the Slovak Academy of Sciences 059 60 Tatranská Lomnica, The Slovak Republic*

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Abstract. A short review of the search for novae in M31 galaxy in 1968–2005 is presented. The results of observations of Nova 2005–13 in M31 are considered as an example.

Key words: photo archive – novae – photometry

1. Studies of novae with small telescopes

Our program of a search for new variable stars in the galaxy M31 and of their study has been under way for more than 30 years. Investigations of novae in external galaxies simplify the study of physical and statistical characteristics of these stars because of practically the same distance and interstellar absorption.

In our Galaxy, we can observe novae located in regions with low interstellar extinction. In nearby galaxies, the study of novae is difficult only in the vicinity of the nucleus. Other parts of galaxies are available for observations, and the distribution of novae in the galaxy is easier to get.

For this and other reasons, a program of a systematic search for novae in M31 was launched in 1967 on the initiative and under supervision of Prof. A. S. Sharov. The program included photographic observations with wide-field telescopes of the Sternberg Astronomical Institute of Moscow State University (the 40/160-cm astrograph and 50/200-cm Maksutov camera of the SAI Crimean Laboratory) and with the 70/240-cm Schmidt telescope at the Baldone Astrophysical Observatory of the Institute of Astronomy of Latvian University (principal investigator Dr. A. A. Alksnis). The main feature of this program was to cover a wide field around M31 with observations.

The filters that reproduced the B photometric system were used at the 50-cm Maksutov telescope with ORWO ZU-2 and ZU-21 130×130 mm photographic plates. These plates covered a field of 3.5×3.5 degrees with the limiting magnitude of about 17–19 mag for 1 hour exposition time. These photographic plates were used for a long time (1961–1993). Between 1993 and 2005 we used plates manufactured in Pereslavl-Zalessky, Russia (chief technologist D. K. Mikhailov).

Due to usage of fine-grained emulsion, it became possible to improve the limiting magnitude of the plates to 21 mag for the best plates.

Studies of the central regions of galaxies were difficult because of strong overexposure. We used two series of plates: with 15-min and 60-min exposure times.

At present, the Moscow plate collection contains 1862 plates and the Baldone plate collection about 600 plates of M31.

For a long time, the plates were examined either in the blink or stereo comparator modes, while the region near the nucleus of M31 was also examined with a simple magnifying glass.

In the frame of this program, **seventy new novae** were discovered in M31 and many novae, discovered by other astronomers, were also investigated. The results of these studies and statistics of novae, an analysis of their physical characteristics on the basis of our unique photo archive were published by A. Sharov in the book "The Andromeda nebula" (1982) and in numerous papers, for example: Sharov, Alksnis (1991, 1992), Sharov (1993), Sharov et al. (2000).

2. Light curve analysis of Nova 2005–13 in M31 as an example of the program

Nova 2005–13 in M31 was discovered on September 9, 2005 by Quimby et al. (2005). We observed the object using CCD cameras in the $BV(RI)_J$-bands with three telescopes, their mirror diameters being from 38 to 60 cm, located in Nauchny (Crimea), during 3–20 September, 2005 (JD 2453617–634). The 50-cm Maksutov telescope was used for photographic observations. The brightness estimates of the nova were based on our photoelectric standards.

The light and colour curves of the nova are displayed in Fig. 1. Some values have been taken from Alksnis et al. (2008) and Burwitz (2005). Note that the data by Burwitz (2005) were earlier available at the web site that currently does not exist.

We see that the decrease of the $B-V$ colour changed to its increase on the tenth day after the outburst. While the $V-R$ colour index increased slowly, the $R-I$ index was practically stable. The $B-V$, $V-R$ diagram (Fig. 2) shows the object displaced from the main sequence (sp G0, the 4th day) to the right and upwards (11th day); by the seventeenth day, the position of the object was shifted downwards. The accuracy of our data was ±0.05–0.1 mag for the 10th–15th days; after that, we can estimate the uncertainty as ±0.1–0.2 mag.

Similar behaviour in $B-V, V-R$ diagram was observed for the classical Nova V2468 Cyg (Shugarov et al., 2010). The large-amplitude dwarf Nova of a WZ Sge type in Aquila (Golysheva, Shugarov, 2014) also travels along the two-colour diagram to the right from the main sequence and then returns to it.

Generally, the tracks of novae in the two-colour diagram differ strongly from star to star. Their behaviour depends on the chemical composition, intensi-

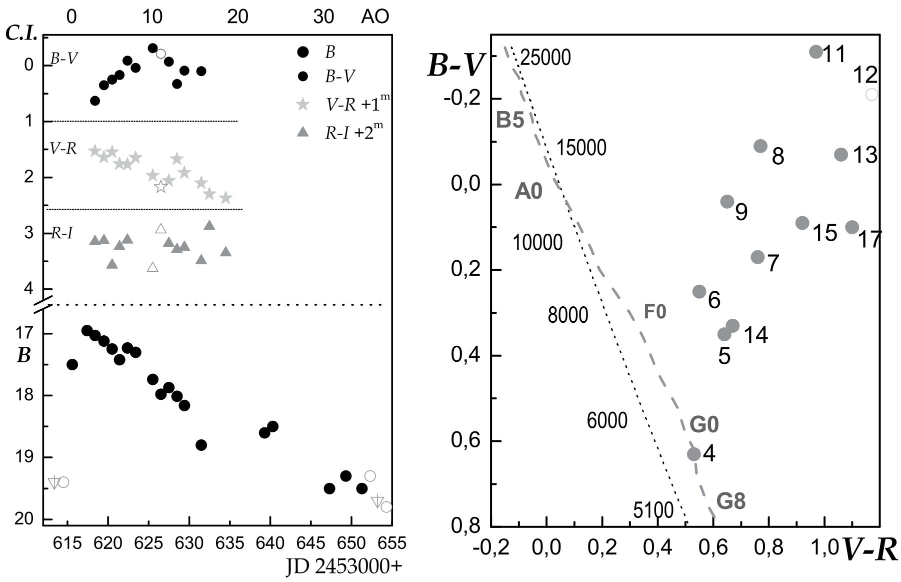

Figure 1. *Left* : The light curve of Nova 2005-13 in the $B-$band and colour curves. The days after outburst (AO) are marked on the top axis. *Right* : The track of the nova on the two-colour diagram. Numbers near the point denote the days AO. The uncertain values are marked as open symbols.

ties of emission lines and their changes, contribution of ejected envelope and a large number of other factors (Duerbeck, Seitter, 1979; van den Bergh, Younger, 1987). Some tracks of classic novae are presented in Chochol et al. (2005, 2006), Goranskij et al. (1997, 2007).

Nova 2005–13 in M31 is a slow nova because $T_2 \sim 18^d$ (for slow novae, $T_2 \gtrsim 13^d$). Using T_2, it is possible to evaluate absolute magnitude of novae using formulas from Schmidt (1957), Della Valle, Livio (1995), Downes (2000). Hence, it appears that $M_V = -8.^m3 \pm 0.3$. Accepting the modern distance modulus for M31, $M - m = 24.^m2$ (Dambis et al., 2013), we get $M_V = -7.^m7 \pm 0.^m1$. The two values are very close. Note that the bright Nova V1500 Cyg in our Galaxy reached $M_V \sim -10^m$ at the maximum of brightness (see Harevich et al., 1975 or Duerbeck, Wolf, 1997).

This study of Nova 2005–13 in M31 is a good example of the research program “Novae in the external galaxies” conducted with small telescopes. In more detail, our work is presented by Zharova et al. (2013).

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