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# NOVAE SEARCH IN M31 WITH NAO ROZHEN TELESCOPES

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**Abstract.** We present a long-term optical search for novae in M31 galaxy, based on observations taken at the 2m RCC telescope and the 50/70cm Schmidt telescope at NAO Rozhen, Bulgaria. Our monitoring of the M31 central region yields ∼15% of all newly discovered novae during the last 5 years. Here we report coordinates and R-band magnitudes (BV-band if available) for 14 newly discovered nova candidates along with a Mira variable, mistaken for nova. Finding charts and light curves are presented. Times of decline ($t_2$) are estimated and Maximum Magnitude - Rate of Decline relationship (MMRD) is constructed.

## 1. INTRODUCTION

Any nova with a well established light curve is very important for using novae as distance indicators and for better understanding of their physics. The nearby galaxy M31 gives an excellent opportunity for novae surveys and in the last years the number of discovered novae in M31 increased, because of the growing number of searching teams. More than 800 novae in M31 are known up to now (Pietsch et al. 2007). Websites[1] dedicated to recent nova discoveries are also available. In Bulgaria, the novae search started in 2004. This paper is the first of a series of papers, based on CCD novae search with NAO Rozhen Telescopes (see also Ovcharov et al. 2009).

## 2. OBSERVATIONS AND DATA REDUCTION

The observations have been carried out at the 2m RCC telescope and the 50/70cm Schmidt telescope at NAO Rozhen, Bulgaria since 2004. Variety of a CCD detectors were used through the years. Data reduction, aperture photometry and astrometry of the objects are performed using standard IRAF routines. After the initial reduction, the individual images are combined and a median-filtered image is subtracted in order to remove the unresolved component of the M31 bulge. Next, the images are inspected manually by comparison with previous ones. Secondary standards in the field of M31, derived from Stetson standards (Stetson 2000) are used for the magnitude calibration and the astrometry of the novae is done using coordinates of reference stars from Massey et al. (2006). The discoveries are reported few hours after the observations at special website for reporting observations of transients -

[1] http://www.cfa.harvard.edu/iau/CBAT_M31.html,
http://www.rochesterastronomy.org/novae.html

Table 1: Observing log of 14 novae, discovered by our team and 1 Mira variable (M31N2007-11g), spectroscopically rejected to be a nova (Tel: 1 - 2m RCC telescope; 2 - 50/70cm Schmidt telescope). Spectroscopic references, if available, are also included in the table (* - 2007ATel.1186; ** - 2007ATel.1314, 2007ATel.1276; *** - 2008ATel.1851; **** - 2008ATel.1673; ***** - 2009ATel.1928). More information on M31N2009-08e can be found in Ovcharov et al. 2009.

| # | Name M31N | Date (UT) yyyy mm dd.ddd | R.A.(J2000) hh mm ss.ss | DEC(J2000) dd ” ”” | Offset from the center of M31 | B mag | $\sigma_B$ mag | V mag | $\sigma_V$ mag | R mag | $\sigma_R$ mag | ATel N | Tel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2004-08c | 2004 08 22.031 | 00 42 42.77 | +41 15 44.4 | 17”.4W 44”.0S | | | 17.83 | 0.03 | | | 330 | 1 |
| | | 2004 08 22.040 | | | | 17.96 | 0.03 | | | | | | |
| 2 | 2004-09b | 2004 09 16.089 | 00 42 44.45 | +41 16 10.5 | 1”.6E 1”.1N | | | 14.68 | 0.05 | | | 334 | 1 |
| | | 2004 09 16.097 | | | | 18.72 | 0.05 | | | | | | |
| 3 | 2004-10a | 2004 10 09.888 | 00 42 51.98 | +41 16 20.8 | 115”.1E 11”.4N | 19.11 | 0.05 | | | | | 346 | 1 |
| | | 2004 10 09.896 | | | | | | 18.72 | 0.05 | | | | |
| 4 | 2005-10b | 2005 11 03.941 | 00 42 41.99 | +41 18 02.1 | 26”.3W 113”.6N | | | | | 18.70 | 0.16 | 651 | 2 |
| | | 2005 11 08.936 | | | | | | | | 19.01 | 0.24 | | |
| 5 | 2006-12c | 2006 12 24.685 | 00 42 43.27 | +41 17 48.1 | 11”.8W 99”.6N | | | | | 19.01 | 0.11 | 973 | 1 |
| | | 2006 12 24.737 | | | | | | | | 19.00 | 0.10 | | |
| | | 2006 12 24.763 | | | | | | | | 18.93 | 0.10 | | |
| 6 | 2007-06a | 2007 06 14.022 | 00 41 58.33 | +41 14 10.6 | 518”.5W 117”.9S | | | | | 19.1 | 0.2 | 1112 | 2 |
| | | 2007 06 15.012 | | | | | | | | 18.91 | 0.16 | | |
| 7 | 2007-07b Fe II* | 2007 07 11.019 | 00 42 45.84 | +41 18 02.7 | 17”.1E 114”.2N | | | | | 18.6 | 0.2 | 1139 | 2 |
| | | 2007 07 15.019 | | | | | | | | 18.92 | 0.29 | | |
| 8 | 2007-11b He/N ** | 2007 11 06.809 | 00 43 52.94 | +41 03 36.0 | 744”E 752”S | | | | | 19.7 | 0.2 | 1267 | 2 |
| | | 2007 11 08.853 | | | | | | | | 18.6 | 0.1 | | |
| 9 | 2007-11g *** | 2007 11 28.716 | 00 44 15.88 | +41 13 51.1 | 1032”.3E 137”.4S | | | | | 18.73 | 0.05 | 1312 | 2 |
| | | 2007 12 07.891 | | | | | | | | 18.84 | 0.06 | | |
| 10 | 2007-11f | 2007 11 28.716 | 00 41 31.52 | +41 07 13.1 | 820”.8W 535”.4S | | | | | 17.84 | 0.03 | 1312 | 2 |
| | | 2007 12 07.891 | | | | | | | | 18.81 | 0.07 | | |
| 11 | 2008-05d **** | 2008 05 28.040 | 00 44 01.86 | +41 04 24.2 | 874”E 704”S | | | | | 19.6 | 0.2 | 1563 | 2 |
| | | 2008 05 29.033 | | | | | | | | 18.7 | 0.2 | | |
| | | 2008 06 06.029 | | | | | | | | 18.11 | 0.06 | | |
| 12 | 2008-06a | 2008 09 01.039 | 00 42 37.67 | +41 12 29.4 | 75”W 219”S | | | | | 18.7 | 0.1 | 1687 | 2 |
| | | 2008 09 02.055 | | | | | | | | 18.89 | 0.16 | | |
| | | 2008 09 03.050 | | | | | | | | 19.06 | 0.17 | | |
| | | 2008 07 08.002 | | | | | | | | 18.38 | 0.12 | | |
| 13 | 2009-02a FeII ***** | 2009 02 06.799 | 00 43 43.85 | +41 36 39.9 | 671”E 1231”N | | | | | 17.20 | 0.03 | 1927 | 2 |
| | | 2009 02 17.777 | | | | | | | | 17.93 | 0.07 | | |
| 14 | 2009-06c | 2009 06 21.019 | 00 42 33.92 | +41 15 52.9 | 117”W 15.6”S | | | | | 18.66 | 0.09 | 2090 | 1 |
| 15 | 2009-08e | 2009 08 25.896 | 00 42 36.23 | +41 18 01.6 | 92”W 113”N | | | | | 18.95 | 0.26 | 2176 | 2 |

http://www.astronomerstelegram.org, which is very important for subsequent spectroscopic observations and more complete study of these objects. Table 1 summarizes the astrometric and photometric data for all the novae, discovered by our team. Spectroscopic references are also included. Fig. 1 shows the finding charts of all discovered objects.

## 3. THE NOVAE AND MIRA VARIABLES

Our novae search team has discovered 14 novae in M31 galaxy since 2004, which yields ∼15% of all newly discovered novae during the last 5 years. M31N2004-09b is the closest to the center of M31 nova ever discovered. A nova, observed by us in September 2008 was found to be re-brightening of M31N2008-06a.

All available data from the literature are summarized to construct novae light curves, even though most of them contain only a few data points. The time of decline can be estimated only for the nova M31N2005-10b (see Fig. 2 - left panel). It's time of decline ($t_2$), i.e. the time need for the brightness to drop with 2 mag, is obtained from the slope of the fit of all data points. The brightest point in the light curve is adopted to be the maximum detected magnitude of the nova. The estimated slope is $0.05 \pm 0.01$ and the $t_2$ is $37.7 \pm 8.1$ days, which classify it as moderately fast nova.

Mira variables have periods greater than 100 days and amplitudes in the optical of up to 11 mag. Thus they can be taken for novae in nearby galaxies. The only reliable way to distinguished them from the novae is by spectroscopy but light curves can be also indicative. Fig. 2 (right panel) shows an example of M31N2007-11g, initially

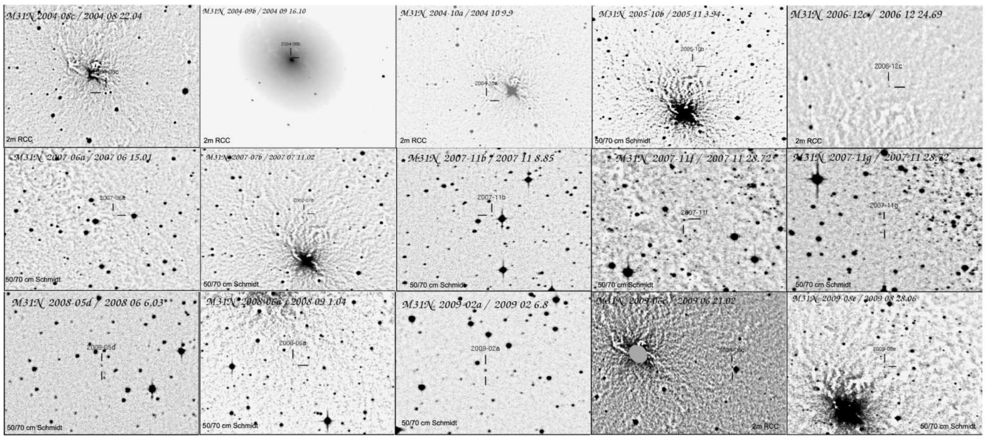

Figure 1: Finding charts of all 14 discovered novae and 1 Mira variable (see the text). 2m RCC and 50/70 cm Schmidt telescope charts have 4×3 arcmin$^2$ and 8×6 arcmin$^2$ scale, respectively. North is to the top and East is to the left.

considered as nova and after next re-brightening in November 2008, the spectroscopic observations reveal long-period Mira variable.

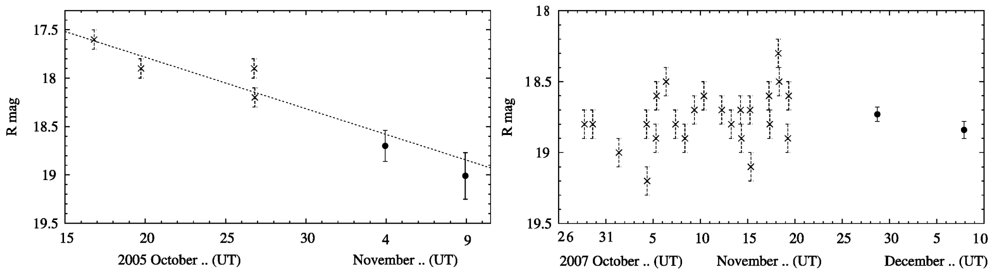


Figure 2: Left: light curve of M31N2005-10b. The nova's time of decline ($t_2$), estimated from the slope of the fit (0.05±0.01), is 37.7±8.1 days (moderately fast nova). Right: light curve of M31N2007-11g (spectroscopically confirmed Mira variable). Circles represent our data and asterisks - the data from Hornoch and Wolf (left panel) and Pietsch et al. (right panel; see http://www.cfa.harvard.edu/iau/CBAT_M31.html).

## 4. MAXIMUM MAGNITUDE – RATE OF DECLINE (MMRD)

Maximum Magnitude - Rate of Decline novae relationship, calibrated for Milky way and M31 (Capaccioli et al. 1989) is expected to be universal. In this case novae can be used as distance indicators. For 16 M31 novae, the MMRD is constructed by Darnley et al. (2006) using SDSS r′ and i′ filters. We transformed R-band magnitude of M31N2005-10b into SDSS r' (Oke and Gunn 1983; Bessell 1979) adopting Milky Way extinction - $A_R = 0.17$ mag (Schlegel et al. 1998). Unfortunately, there is not enough data points to investigate in greater detail the true form (linear or S-shaped) of r′-band MMRD relationship for M31 (see Fig. 3). Correct determination of the maximum brightness and extinction corrections are of great importance for a better calibration.

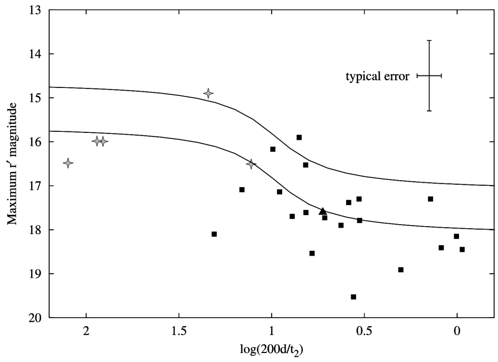


Figure 3: r′-band MMRD relationship for M31. Squares represent data from Darnley et al. (2004), stars represent the estimations of Trifonov (2009) and the triangle is our estimation for M31N2005-10b (see Section 4). The region between the two S-shaped lines represents the best fit Galactic MMRD (Capaccioli et al. 1989).

## 5. CONCLUSIONS

Five years monitoring of the central region of M31 galaxy with NAO Rozhen telescopes led to the discovery of 14 novae and detection of 1 Mira variable at maximum brightness. Combining our data with all available external photometry is not enough, in most cases, to construct a well-defined nova light curves and to define the real maximum brightness, which is very important for the calibration of the MMRD relationship. The time of decline for the nova M31N2005-10b is estimated from the constructed light curve ($t_2$=37.7±8.1 days). This result is in good agreement with the expected S-shaped dependence of MMRD for M31 novae, but still new data are need for a precise calibration.

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### References

Bessell, M. S.: 1979, *PASP*, **91**, 589.
Capaccioli, M., della Valle, M., Rosino, L., D′Onofrio, M.: 1989, *AJ*, **97**, 1622
Darnley, M. J., Bode, M. F. et al.: 2004, *MNRAS*, **353**, 571.
Darnley, M. J., Bode, M. F. et al.: 2006, *MNRAS*, **369**, 257.
Massey, P., Olsen, K., Hodge, P. et al.: 2006, *AJ*, **131**, 2478.
Oke, J. B. and Gunn, J. E.: 1983, *ApJ*, **266**, 713.
Ovcharov, E. et al.: 2009, *6th SREAC Meeting, 28-30 Sept 2009, Belgrade, Serbia* (in press).
Pietsch, W., Haberl, F. et al.: 2007, *A&A*, **465**, 375.
Schlegel, D. J., Finkbeiner, D. P., Davis, M.: 1998, *ApJ*, **500**, 525.
Stetson, P.: 2000, *PASP*, **112**, 925.
Trifonov, T.: 2009, M.S. thesis, University of Sofia.