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FOUR AUGUST 2009 NOVAE IN M31 – LIGHT CURVES, COLOURS AND MMRD

E. P. OVCHAROV[1], A. VALCHEVA[1], P. NEDIALKOV[1], T. TRIFONOV[1], N. KACHAROV[1], R. BACHEV[2] and Ts. GEORGIEV[2]

[1]*Department of Astronomy, University of Sofia, 5 James Bourchier Blvd., 1164 Sofia, Bulgaria*
E–mail: evgeni@phys.uni-sofia.bg

[2]*Institute of Astronomy, BAS, Sofia 1784, Bulgaria*

Abstract. This work is the second one of a series of papers based on observations, carried out by the Bulgarian novae search team (Valcheva et al. 2009). Here we present photometry and astrometry of four novae in the M31 galaxy, discovered in August 2009, one of them by us. The observations were performed in period of 11 nights in the second half of August with the 50/70 cm Schmidt telescope and 60 cm Cassegrain telescope at AO Belogradchik, respectively. The available data (optical and spectroscopic) from other sources are also included. Finding charts and light curves in several pass- bands (BVR) are presented. The times of decline (t_2) are estimated and the Maximum Magnitude - Rate of Decline relationship (MMRD) is constructed.

1. INTRODUCTION

Novae surveys in M31 galaxy are very important for specifying the MMRD relationship (Zwicky 1936, della Valle and Livio 1995). Therefore, the construction of light curves, covering long interval of time and wide range of magnitudes is one of the most important aims in the novae monitoring campaigns. The observational activity in recent years makes this aim more achievable not only for major studies, based on catalogues (Darnley et al. 2004, 2006), but even for small telescope monitoring programs (Hatzidimitriou et al. 2007). Moreover, spectroscopy is the most straightforward way to confirm a nova but feasible only with larger telescopes. For the smaller ones there are other useful methods, like observations in H_α and broad– band photometry, covering long time intervals. In this study we present light curves in BVR pass–bands, that can also give us a rough information about the energy distribution.

2. OBSERVATIONS AND DATA REDUCTION

The observations are carried out with the 60 cm Cassegrain telescope at the AO Belogradchik (4 nights) and with the 50/70 cm Schmidt telescope (5 nights) at the NAO Rozhen, Bulgaria, equipped with FLI PL09000 and FLI PL16803 CCD cameras, respectively. All nine nights were clear and photometric, without high humidity and with a typical seeing, less than 2 arcsec, the total integration time was split into

Table 1: Journal of observations. NAO 50/70 – 50/70 cm Schmidt telescope at NAO Rozhen with field of view (FoV) of 73.7 x 73.7 $arcmin^2$ and images' exposure time of 3x300 sec; AO 60 – 60 cm Cassegrain telescope at AO Belogradchik with FoV – 16.8 x 16.8 $arcmin^2$ and images' exposure time of 10x120 sec.

Name M31N	Date(UT) yyyy mm dd.ddddd	RA(J2000) hh mm ss.ss	DEC(2000) dd ” “‘	Offset from the M31 center	B mag	σ_B mag	V mag	σ_V mag	R mag	σ_R mag	Telescope
1 2009-08a	2009 08 21.02222	00 42 58.16	+41 17 30.3	156″.0E					18.61	0.19	AO 60
	22.01181			81″.8N					18.23	0.12	AO 60
	22.96389								18.19	0.13	AO 60
	25.89583								18.98	0.29	NAO 50/70
	26.07986								19.15	0.27	NAO 50/70
2 2009-08b	2009 08 25.89583	00 44 09.90	+41 48 52.3	964″.9E					18.86	0.08	NAO 50/70
	26.07986			1963″.8N					18.95	0.07	NAO 50/70
	26.89931								18.92	0.09	NAO 50/70
	27.08160								19.24	0.11	NAO 50/70
	27.07118						19.69	0.18			NAO 50/70
	28.05903								19.11	0.08	NAO 50/70
	29.08086								19.16	0.11	NAO 50/70
	29.09306						19.62	0.20			NAO 50/70
3 2009-08c	2009 08 19.93264	00 42 41.14	+41 17 00.3	35″.9W					17.20	0.10	AO 60
	21.02222			51″.8N					17.33	0.11	AO 60
	22.01181								17.31	0.11	AO 60
	22.96389								17.28	0.11	AO 60
	25.89583								17.50	0.15	NAO 50/70
	26.07986								17.48	0.12	NAO 50/70
	26.89931								17.44	0.17	NAO 50/70
	27.08160								17.56	0.15	NAO 50/70
	27.07396				18.74	0.26					NAO 50/70
	27.07118						18.09	0.21			NAO 50/70
	28.05903								17.52	0.13	NAO 50/70
	28.06528				18.37	0.19					NAO 50/70
	28.07257						17.89	0.23			NAO 50/70
	29.07986								17.58	0.16	NAO 50/70
	29.08958				18.89	0.27					NAO 50/70
	29.09306						18.00	0.21			NAO 50/70
	29.85069								17.64	0.20	NAO 50/70
	30.05694								17.62	0.15	NAO 50/70
	30.07569				18.75	0.21					NAO 50/70
	30.08646						18.24	0.21			NAO 50/70
4 2009-08e	2009 08 25.89583	00 42 36.23	+41 18 01.6	91″.2W					18.95	0.26	NAO 50/70
	26.07986			113″.1N					18.61	0.15	NAO 50/70
	26.89931								18.15	0.12	NAO 50/70
	27.08160								18.07	0.10	NAO 50/70
	27.07396				18.24	0.09					NAO 50/70
	27.07118						18.23	0.11			NAO 50/70
	28.05903								18.04	0.09	NAO 50/70
	28.06528				18.45	0.13					NAO 50/70
	28.07257						18.46	0.19			NAO 50/70
	29.07986								17.90	0.10	NAO 50/70
	29.08958				19.11	0.17					NAO 50/70
	29.09306						18.38	0.16			NAO 50/70
	29.85069								18.07	0.13	NAO 50/70
	30.05694								18.28	0.12	NAO 50/70
	30.07569				19.13	0.15					NAO 50/70
	30.08646						18.76	0.17			NAO 50/70

a few separate frames (Table 1). The data reduction, photomerty, astrometry and calibrations are described in Valcheva et al. (2009).

3. THE NOVAE

All presented novae are spectroscopically confirmed FeII-type novae. The discoveries and some additional information for the novae are reported in the M31 novae website - *www.cfa.harvard.edu/iau/CBAT_M31.html*, also in *www.mpe.mpg.de/ ∼ m31novae/opt/m31/M31_table.html* and in the ATel # 2174, 2165, 2166, 2176 (our discovery), 2208 and 2213. The published photometric data are obtained mostly without filter, rarely there are some H-alpha data and a few Johnson/Cousins data points. The finding charts of the novae are based on one of our R-band images (Fig. 1).

4. FROM LIGHT CURVES TO MMRD

We used all published data up to 20 September, except our data, to construct the novae light curves (Fig. 2). We adopted photometric error of 0.1 mag for accuracy of

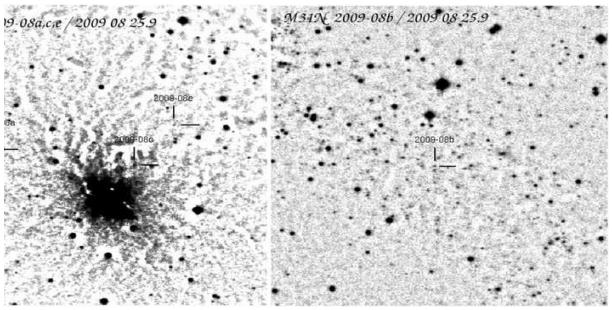

Figure 1: Finding charts of the novae. The image's field of view is 8 x 8 $arcmin^2$.

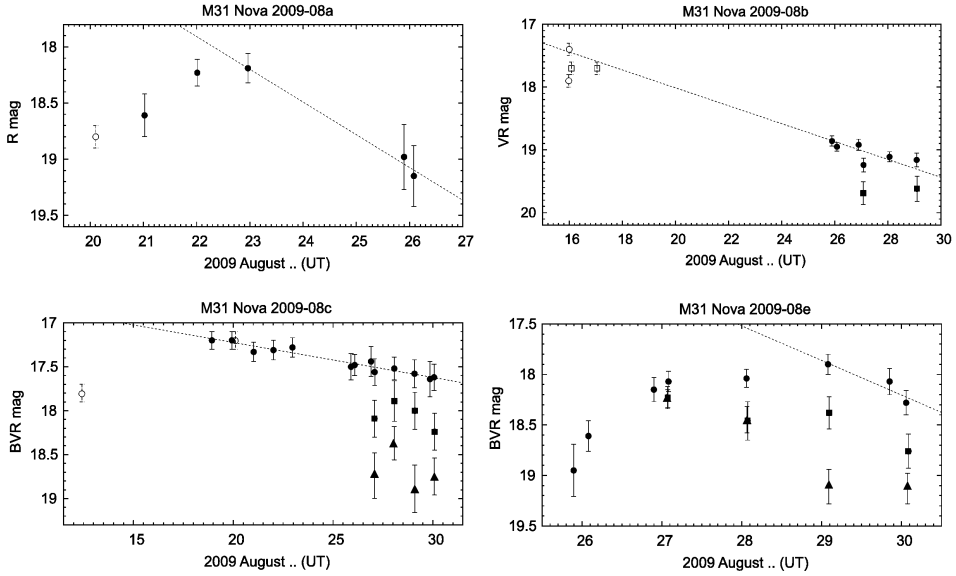

Figure 2: Light curves of the novae. The empty symbols represent other autors data and the filled ones – our data. BVR magnitudes are represented by triangles, squares and circles, respectively. The aditional data for *a* and *c* novae are from K. Hornoch (A. Galad), V-data for the nova *b* are from C. Segara and R-data are from D. Rodriguez (17.9 mag) and F. Pena (17.4 mag). The fits of the R magnitudes after the brightest observational points are shown. The slopes and the times of decline are: 2009-08a: slope = 0.29 ± 0.03, t_2 = 6.9 ± 0.8 days; 2009-08b: slope = 0.14 ± 0.01, t_2 = 14.0 ± 1.2 days; 2009-08c: slope = 0.04 ± 0.01, t_2 = 50.2 ± 3.6 days; 2009-08e: slope = 0.34 ± 0.12, t_2: 5.8 ± 2.0 days.

the published data. In contrast to the nova 2009-08c, the nova 2009-08e gets redder for a few days possibly due to more rapid cooling related to its faster decline. The times of decline - t_2 are estimated under the assumption that the brightest observational point is the maximum magnitude of the nova.

The derived data are transformed into r′-band system and combined with data of Darnley et al. (2004) on the MMRD diagram (Fig. 3). Two of the novae have lower brightness when compared to the expected maximum light for same time of decline.

The possible explanations can be that the real maximum brightness was missed or it is a highly extincted nova.

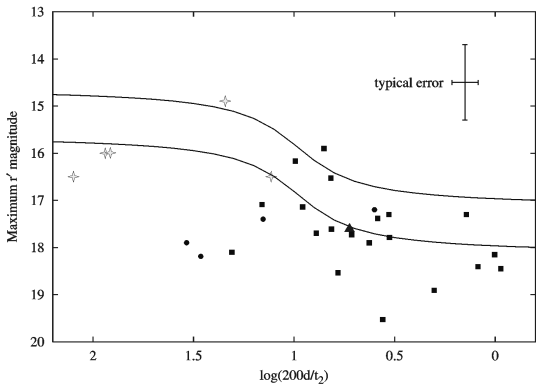

Figure 3: MMRD relationship. The squares represent data of Darnley et al. (2004), the stars show the estimations of Trifonov (2009), the triangle is the estimation from Valcheva et al. (2009) and the circles are our data. R-band is transformed into SDSS r′ (Oke and Gunn 1983; Bessell 1979) and extinction from Milky Way – A_R= 0.17 mag has been accounted for (Schlegel et al. 1998). The region between the two S-shaped lines represents the best fit Galactic MMRD (Capaccioli et al. 1989).

5. CONCLUSIONS

Observational data and light curves for four spectroscopically confirmed FeII-type novae are presented. Colour changes are noticeable for one of the novae. Times of decline are estimated and used to construct MMRD relationship together with additional data points. Two of the novae show lower than the expected brightness.

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