Observations of Novae From ROAD

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Abstract The author discusses observations of galactic novae and some extragalactic supernovae from his remote observatory ROAD (Remote Observatory Atacama Desert) he commenced in August 2011 with Nova Lupi 2011 (PR Lup). The observed novae are mainly chosen according to *AAVSO Alert Notices* and *AAVSO Special Notices* as published on their website. Examples of dense observations of different novae are presented. The focus goes to the different behaviors of their light curves. It also demonstrates the capability of the remote observatory ROAD.

1. Introduction

Galactic novae and extragalactic supernovae seem to be a very intensive field of research in professional astronomy. Just recently (2013) a conference on Stella Novae: Past and Future Decades was held in Cape Town (http://www.ast.uct.ac.za/stellanovae2013/). It was mentioned in one of the presentations, which are available on the internet, that more than 700 refereed papers on the subject of novae were published in the past decade. The author started to observe novae based on requests from the AAVSO and different mailing list (mainly VSNET and CVNET). Due to the very good observing possibilities at the author's remote observatory ROAD (Remote Observatory Atacama Desert) (300+ clear nights per year) intense observations of those stars were possible. Those observations are mainly done as snapshots every clear night and sometimes also as time series if of interest. During the many clear nights at the remote site a lot of data are being gathered on many stars. In the present paper a selection of novae is presented with their respective light curves based on data from the AAVSO including those of the author.

2. Observatory

The remote observatory in Chile houses a 40-cm f/6.8 Optimized Dall-Kirkham (ODK) from Orion Optics, England. The CCD camera is from FLI and contains a Kodak 16803 CCD chip with 4k × 4k pixels of 9 μm size. The filter wheel is also from FLI and contains photometric BVI filters from Astrodon.

Figure. 1. Photo of the remote telescope installation in Chile in operation at night.

In Belgium, where the author lives, a roll-off-roof observatory is used in addition for variable star observations from the Northern hemisphere, if it ever gets clear. Belgium is famous neither for its good weather nor its lack of light pollution, nevertheless there is still some room for interesting observations. The telescope in Belgium is a Celestron C11 working at f/6.3. The telescope is equipped with an SBIG ST8XME CCD camera using BVRI photometric filters. Soon a Staranalyser SA200 grid for low resolution spectroscopic investigations will also be installed.

Figure 1 shows the remote telescope in Chile in operation at night. The telescope is housed in a clamshell dome, making easy movement of the telescope possible without the need to follow with a shutter of a normal dome.

Images of a night's session are acquired with CCDCommander automation software. Further analysis in terms of determination of the brightness of the stars is done using a program developed by de Ponthière (2010). Differential aperture photometry is used to determine the magnitudes of variable and comparison stars. Uncertainties are determined from the signal-to-noise ratio using Poisson and background noise as well as CCD gain. The calculation is performed in accordance to relation (12) of Newberry (1991). The data are then finally submitted to the AAVSO.

3. Novae

The observed novae were mainly chosen according to announcements in *AAVSO Alert Notices* and *AAVSO Special Notices* (AAVSO 2008–2014). The observations at the remote site began on August, 1, 2011. The first nova which was observed was Nova Lupi 2011 (PR Lup). But before we start to discuss the observations we should look at what is known about novae in literature. Since the author is not a specialist in this field, nor a professional astronomer, he has to rely on the internet and e-mail information on relevant literature. The most comprehensive paper is probably the one of Strope *et al.* (2010). It contains a catalogue of 93 nova light curves with a classification of the

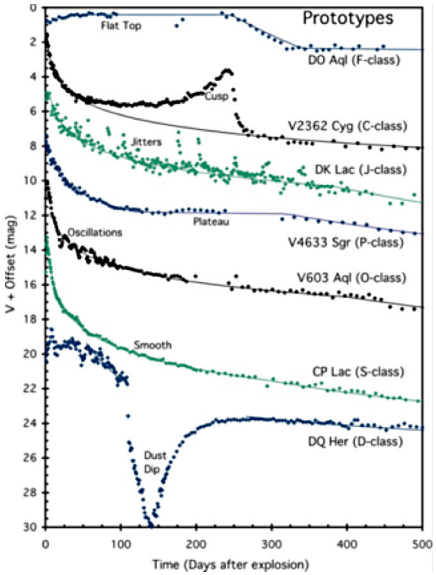

Figure 2. Different prototypes of novae based on the form of their light curve.

light curves (Figure 2) and a list of properties of the novae, like peak magnitudes, decline speeds etc. One of the problems mentioned in this paper is the fact that only very few of the brightest novae were followed more extensively down to quiescence mainly by amateurs and only two of them by professionals. Hence, there is still room for amateur observations if they are done in a more systematic way. The light curves of novae covered in this paper are mainly based on observations from the AAVSO international database. The database contains more than double the number of novae, but only those covered in the article have a decent number of observations. In the paper the light curves could be classified according to seven different types, which are called classes. The prototype light curves of the different classes are given in Figure 2.

In the following a few examples of novae observations from the remote observatory are given. Not all classes could be observed. All images shown are based on the author's observations and additional observations found in the AAVSO International Database (AAVSO 2014). BVI photometric filters were used.

4. Nova Cen 2012-2 (TCP J14250600-5845360)

A new star in Centarus was discovered by J. Seach (Chatsworth Island, NSW Australia) on April 4.765, 2012, using a DSLR with a 50-mm f/1.0 lens. It was the second nova discovered in the constellation Centaurus in 2012.

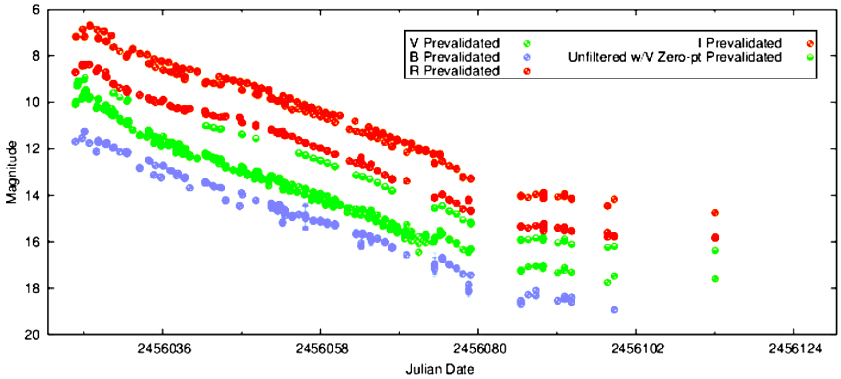

Figure 3. Light curve of Nova Cen 2012-2 (TCP J14250600-5845360) based on observations found in the AAVSO database. Part of the I- and V-band observations were taken remotely at ROAD.

It was assigned the identifier TCP J14250600-5845360 and was published on the Transient Object Confirmation Page of the IAU Central Bureau for Astronomical Telegrams (CBAT TOCP; http://www.cbat.eps.harvard.edu/unconf/tocp.html). Due to the very short focal length of only 50 mm the position of the nova was not very well known. A better astrometric position was determined with the 2-m Faulkes Telescope South by E. Guido, G. Sostero, and N. Howes. A spectroscopic confirmation observation of the novae was performed by T. Bohlsen.

As one can see from the light curve in Figure 3, the nova was discovered before maximum light. Observations at ROAD were started as early as April 5.902, hence just a bit more than one day after the initial discovery. Observations were continued over 46 nights in V and I band filters (Figure 3). A smooth behavior of the light curve was observed (S-type light curve).

5. Nova Mon 2012 (V959 Mon)

Nova Monocerotis 2012 (V959 Mon) was discovered on August, 9.8048 UT, 2012, by S. Fujikawa (Kagawa, Japan) using a 105-mm FL camera lens and a CCD camera at magnitude 9.4 with a clear filter. It was assigned the CBAT TOCP identifier PNV J06393874+0553520. Remote observations at ROAD started on August 12.918 using V and I band filters. The nova was followed both from Chile and from the Astrokolkhoz Observatory, New Mexico. Both snapshot and long time series observations were done (Figure 4). From New Mexico, using two different telescopes and observing the stars over its full observing period during several nights, BVRI time series could be acquired. An analysis of those time series confirmed the 7.1-hour period of this star (Hambsch *et al.* 2013) discovered in UV/X-ray observations of this nova (Osborne *et al.* 2013). As one can see the observations have continued from

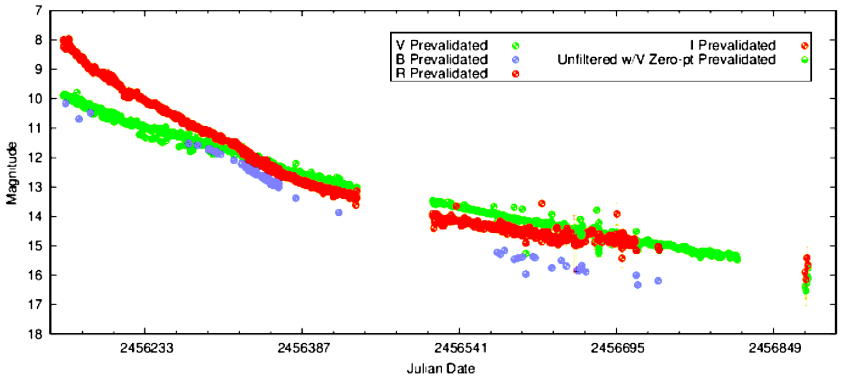

Figure 4. Light curve of Nova Mon 2012 (V959 Mon) based on observations found in the AAVSO database. Most of the observations were taken remotely at ROAD.

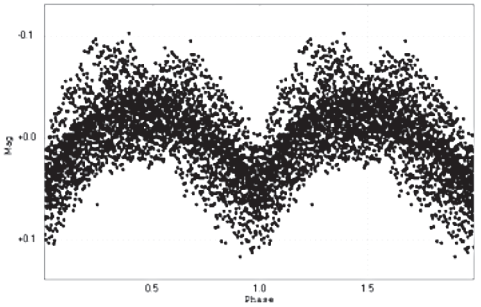

Figure 5. Phase diagram of Nova Mon 2012 (V959 Mon) with P = 0.29575 ± 0.0005 d = 7.098 h.

the discovery until now, only interrupted by the fact that the star's observing season ended. There is a clear behavior visible: that I-band magnitudes do not behave in a way parallel to the V-band magnitudes. Maybe this nova could be regarded as a member of either the smooth or plateau class.

Figure 5 shows the phase diagram of the time series observations from New Mexico. A period of P = 7.098 h was used to generate the image.

6. Nova Oph 2012 (V2676 Oph)

This nova in Ophiuchus was discovered by H. Nishimura (Shizuoka-ken, Japan) on Mar. 25.789, 2012, using a Canon 200mm f/3.2 lens with a Canon EOS 5D digital camera. It was assigned the CBAT TOCP identifier PNV J17260708-2551454. On March 27.74 low-resolution spectra were taken at the 1.3-m Araki telescope at the Koyama Astronomical Observatory (KAO) that confirmed the new object as a classical nova.

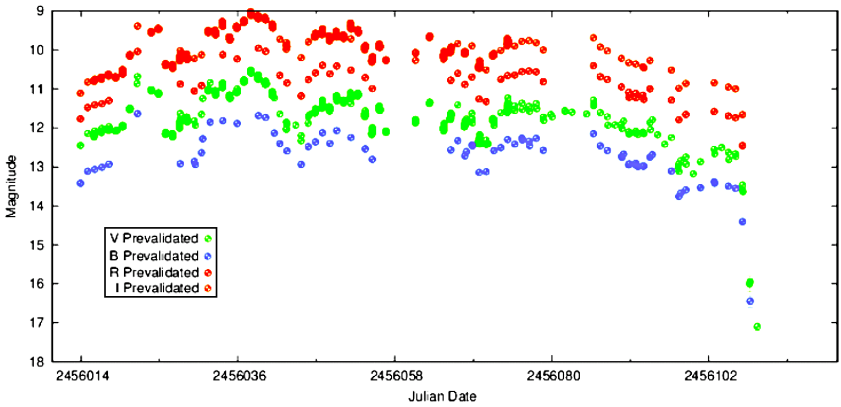

Figure 6. Light curve of Nova Oph 2012 (V2676 Oph) based on observations found in the AAVSO database. Part of the I- and V-band observations are taken remotely at ROAD.

Observations started at ROAD on March 28.865 UT using V- and I-band filters. Observations were conducted as snapshots during 42 nights. Figure 6 shows the light curve based on all observations found in the AAVSO International Database. Clearly the shape of the light curve is very different to the previous ones and shows a kind of jitter or oscillations, yielding a light curve showing minima and maxima until after about 85 days, when an abrupt decline starts. Unfortunately no further observations were performed after this drop.

7. Nova Sgr 2014 (PNV J18250860-2236024)

Another example of a recently newly discovered nova in Sagittarius is Nova Sgr 2014 (PNV J18250860-2236024). It was discovered by S. Furuyama, (Ibaraki-ken, Japan) on January 26.857, 2014, using a 200-mm f/2.8 lens and CCD camera. A low-dispersion spectrum (R about 980 at 650 nm) of the object was obtained using the 2-m Nayuta telescope at the Nishi-Harima Astronomical Observatory, Japan, which confirmed the nature of the object as a nova.

Observations started on January 28.393, using V- and I-band filters. Observations were conducted as snapshots one-and-a-half days after the discovery. Observations are still ongoing as the nova is still bright.

Figure 7 shows the light curve based on all observations sent to the AAVSO. From ROAD the majority of data are taken for this star. From the light curve it is clear that oscillations in the brightness of the nova exist and it belongs to the oscillation class. Based on the most recent observations the light curve has changed and a drop in magnitude in both I- and V-bands is visible. It will be interesting to see the behavior of this star in the months to come.

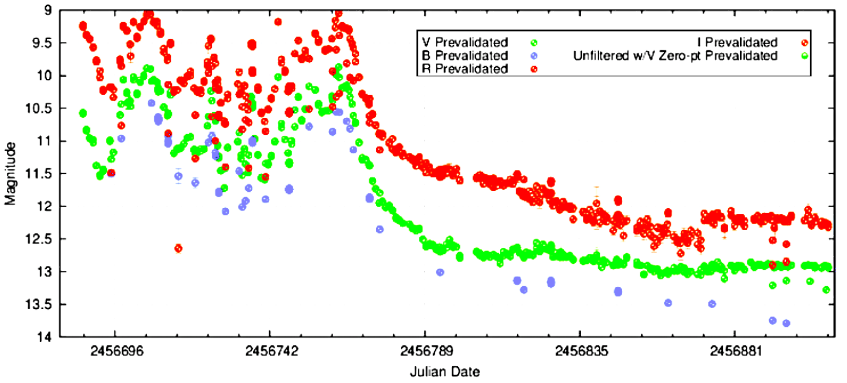

Figure 7. Light curve of Nova Sgr 2014 (PNV J18250860-2236024) based on observations found in the AAVSO database. Most of the I- and V-band observations are taken remotely at ROAD.

8. Supernova SN 2013aa in NGC 5643

SN 2013aa in NGC 5643, a galaxy in the constellation Lupus, was observed after an e-mail alert. It was discovered by S. Parker (Canterbury, New Zealand) on February 13.621, 2013. Its identifier is PSN J14323388-4413278. In Figure 8 observations of the AAVSO database are shown of which observations from ROAD form the majority. Observations started as snapshots on February 15.895 UT in V- and I-band filters. From Figure 8 it is obvious that in the I band the light curve showed a second brightening about 40 days after maximum brightness. Also, the V maximum brightness came after the I-band maximum by about 10 days. Then the supernova was brighter in V for about 20 days compared to the I-band brightness.

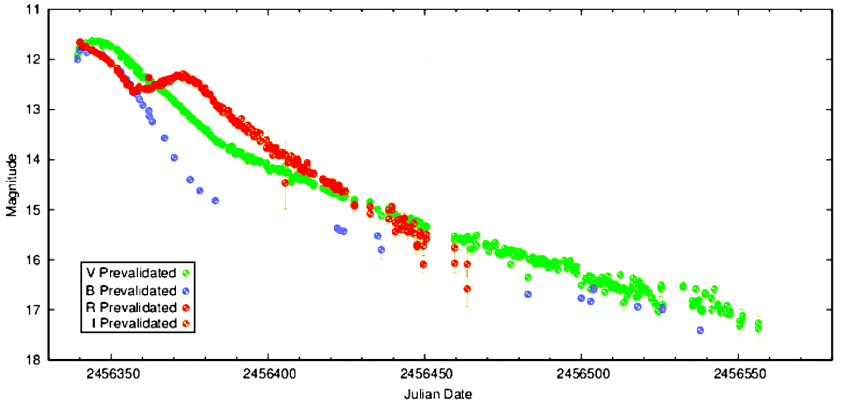

Figure 8. Light curve of Supernova SN 2013aa in NGC 5643 based on observations found in the AAVSO database. Most of the I- and V-band observations are taken remotely at ROAD.

Observations extended over a period of 171 nights with only a few interruptions due to bad weather.

9. Nova Trianguli Australis 2008 (NR TrA)

This nova was observed in collaboration with the Center for Backyard Astrophysics (CBA). The nova was shining at about visual magnitude 8.5 in April 2008. Time series observations were started March 27, 2013, and lasted for 33 nights. The present brightness of this nova is around magnitude 15.5. Figure 9 shows the phase diagram of the observations. This figure was generated using a period of 5.2599 h ± 0.0013.

This period is very close to the one observed at the CTIO 1.3-m telescope in Chile. This CTIO result was presented at the conference mentioned in the introduction in 2013 in Cape Town, South Africa. The presentations given can be found on the website of the conference. It shows that with amateur equipment and many clear nights, results can be achieved which are comparable to professional investigations.

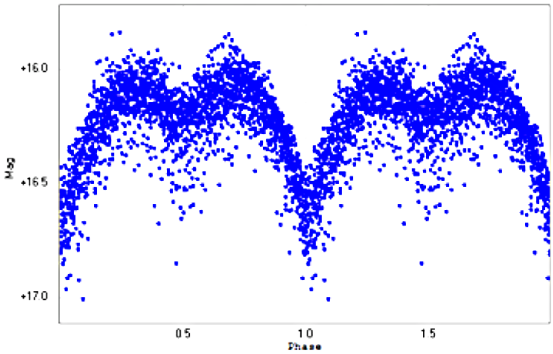

Figure 9. Phase diagram of NR TrA (Nova TrA 2008) with P = 5.2599 h ± 0.0013.

10. Conclusion

The remote observatory under pristine skies in the Atacama Desert opens up many possibilities to observe variable stars. Intensive follow-up observations over many days, weeks, or even months are possible due to the stable weather conditions. The examples given show impressively what is possible. Collaborations are searched for in order to contribute to scientific research of common interest.

11. Acknowledgements

For this research the information given in *AAVSO Alert Notices* and *AAVSO Special Notices* has been used. Also, the information given in the International Variable Star Index (VSX), operated by the AAVSO, was used.

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