ROAD (Remote Observatory Atacama Desert): Intensive Observations of Variable Stars

Franz-Josef Hambsch
VVS, AAVSO, BAV, GEOS
Oude Bleken 12, B- 2400 Mol, Belgium
M31@telenet.be

Abstract

The author discusses his new remote observatory under pristine skies and the intensive observations of variable stars he is accomplishing. The stars under investigations are mainly cataclysmic variables in request of AAVSO, CBA and VSNET alerts as well as other type of stars like RR Lyrae stars. Examples of dense observations of different cataclysmic variables as well as a RR Lyrae star are presented. The focus goes to the first bright outburst of SV Ari (Nova Ari 1905) since its discovery as well as the first outburst of UGWZ candidate BW Scl. Also results for VW Hyi, another cataclysmic variable will be shown. Furthermore an intensively observed RR Lyrae star will be highlighted.

1. Introduction

It is an amateur astronomers dream to observe under pristine dark and clear skies nearly every night like at the sites where the professional astronomical observatories are located. Such a dream normally never comes true. However, modern techniques and infrastructures in most countries make it possible nowadays to observe from remote sites using off the shelf technology. The author installed a remote observatory under the dark skies of the Atacama Desert close to the town of San Pedro de Atacama. The telescope is housed at SPACE (San Pedro de Atacama Celestial Exploration; *http://www.spaceobs.com/index.html*). The owner is an amateur astronomer, too who formerly worked at ESO at the big telescope sites in Chile. In 2003 he started SPACE, which has been extended to telescope hosting since a couple of years.

I got in contact with him in 2009 and decided to put my observatory at his place.

Unfortunately, delivery of the telescope took much longer than anticipated and only in 2011 July, the dome, mount and telescope could be installed. Since 2011 August 1, the remote observatory is producing data every clear night. So far in the less than 8.5 month of operation this amounted to about 220 data taking nights. Not bad, is it not?

I am collaborating with J. Patterson from the Center of Backyard Astrophysics (CBA) and T. Kato from the VSNET email alerts on the observation of cataclysmic variable stars.

Furthermore I am interested in observing RR Lyrae stars. Here, I collaborate with the Groupe Europeen d'Observations Stellaires (GEOS). In Belgium I am member of the Werkgroep Veranderlijke Sterren (WVS) on High Amplitude Delta Scuti (HADS) stars. I am also member of AAVSO and the German Bundesdeutsche Arbeitsgemeinschaft für Veränderliche Sterne (BAV).

During the many clear nights a lot of data is being gathered on many stars. Since the space here is limited I restrict myself to some highlights, the outburst of SV Ari, BW Scl and VW Hyi. Also a RR Lyrae type star with a strong Blazhko effect will be mentioned.

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 4kx4k pixels of 9 m size. The filter wheel is also from FLI and contains photometric BVI filters from Astrodon.

In Belgium, where I live, I have a roll-off-roof observatory in my backyard, housing three scopes for variable star observations if it ever gets clear. Belgium is neither famous about its weather nor its light pollution, nevertheless there is still some room for interesting observations. Those telescopes are a Celestron C14 and C11 and a Meade ACF14. The telescopes are equipped with two SBIG ST8XME and an STL-11kXM CCD camera using BVRI photometric filters.

To make the telescope park complete I also collaborate with AAVSO in sharing an AAVSONet telescope (a Meade 30-cm SCT) with an SBIG ST9-XME CCD.

Fig. 1 Photo of the remote telescope installation in Chile.

Fig. 1 shows an image of the remote telescope in Chile. It 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 either acquired with ACP or CCDCommander automation software. Further analysis in terms of determination of the brightness of the stars is done using a program developed by P. de Ponthierre (2010). The data are then finally submitted to the AAVSO.

3. SV Aries (Nova Aries 1905)

As a first example, I show the results of the campaign on SV Ari. SV Ari was discovered on 1905 Nov. 6 by M. and G. Wolf in Heidelberg, Germany, at a photographic magnitude of 12.0. It was reported that it had brightened from mag 22.1. Kimpel and Jansch reported a possible sighting in 1943 September at a magnitude of 15.7, but this was not confirmed. No brightness increase has been observed for this star ever since.

Then on 2011 August 2.788 UT, R. Stubbings observed the field of SV Ari and saw an object at magnitude 15.0. He sent an alert via the mailing list cvnet-outburst around to ask for confirmation. Also via the VSNET mailing list the information of the outburst of SV Ari was spread. This lead to confirmation by G. Masi (2011) and R. Fidrich (2011). I saw those alerts via VSNET and since G. Masi immediately took a time series and observed superhumps, I also decided to go after this star and started a time series at Aug., 2.844 UT just 1.34 h after the initial discovery. A first analysis of the data of G. Masi by the Kyoto team (Ohshima *et al*., 2011) showed that the star is probably an SU UMa type dwarf nova with a superhump period of about 1.54 h. The present outburst seems also not as bright as the one during the discovery of magnitude 12. However, another mail from T. Kato (2011) on VSNET reported that probably the original brightness estimate was too optimistic as it seems that many brightness determinations of M. Wolf were about 2 magnitudes too bright.

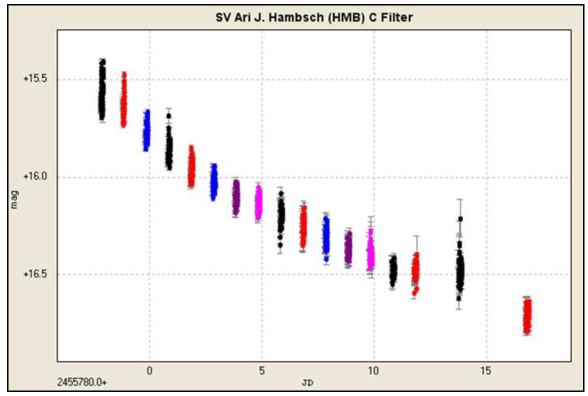

Fig. 2 Light curve of the observations of SV Ari over a period of more than two weeks.

Fig. 2 shows the observations I took of this star during a period of more than two weeks. During this period the star dropped more than one magnitude in brightness. It is also clearly visible from this figure that individual nights show brightness variations of about 0.3 magnitudes.

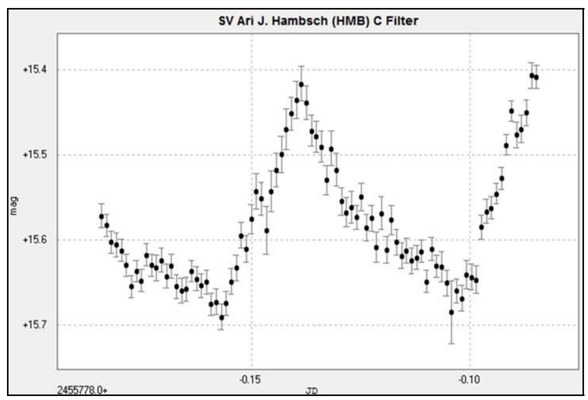

Fig. 3 Light curve of the observations of SV Ari over a period of more than two weeks.

Fig. 3 shows the time series observation during the first night. Clearly a superhump of 0.3 magnitudes is visible. The magnitude of the superhumps reduced to about 0.15 magnitudes after a couple of days.

Based on the analysis by the Kyoto team, there have been distinct stages in the evolution of superhumps in SV Ari. The mean period before Aug. 4 was 0.05574(18) d, which has since shortened to 0.05519(5) d. Later data also showed that SVAri was gradually declining (~0.05 mag / day). This seemed very slow for an ordinary SU UMa type dwarf nova. Thus probably this object may be a WZ Sge type dwarf nova. This information is based on e-mail exchanges via VSNET. Towards the end of 2011 August, SV Ari had dimmed towards magnitude 18.

4. BW Sculptoris

Another example of an intensively followed star is BW Sculptoris, which went in its first ever observed outburst on October 21. BW Scl is also a cataclysmic variable star. The AAVSO published on the same day a special notice #261 mentioning the outburst of BW Scl. It was visually observed by M. Linnolt on Oct. 21.3146 at a magnitude of 9.6 (vis). The outburst was confirmed by A. Plummer at mag. 9.4 (vis). The star has conflicting classifications in literature and is probably a WZ Sge-type dwarf nova. On Oct. 25 AAVSO issued an Alert Notice 449 concerning this outburst.

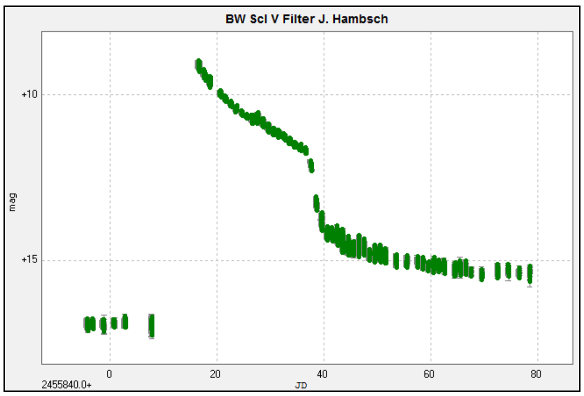

Fig. 4 Light curve of the observations of BW Scl over a period of nearly three month..

The star was followed by me already in the pre-outburst phase. However, I missed the outburst as I thought the star is not doing much so stopped observations on Oct. 14, just a week before the outburst took place. Of course I restarted observations immediately after the news was spread and followed the star over a period of 2.5 month. Fig. 4 shows the development of the brightness over the full observing period.

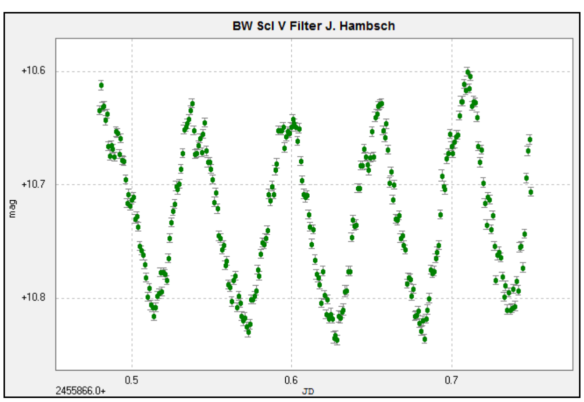

Fig. 5 Light curve of the observations of BW Scl over a period of nearly three month.

After a few days nice superhumps developed of about 0.25 mag as can be seen in Fig. 5. After a week into the outburst the early superhump period was determined to be 0.054308(3) by Ohshima *et al.* (2011a). After a rapid declining phase from mag. 11.7 to about mag. 14 starting at about JD 2455877 again nice superhumps of 0.3 mag developed.

5. VW Hydri

On request by professional astronomers, I started observations of VW Hyi just as it went into superoutburst, although that was a surprise to the pros as the superoutburst was not expected yet. My observations triggered satellite observations of the star

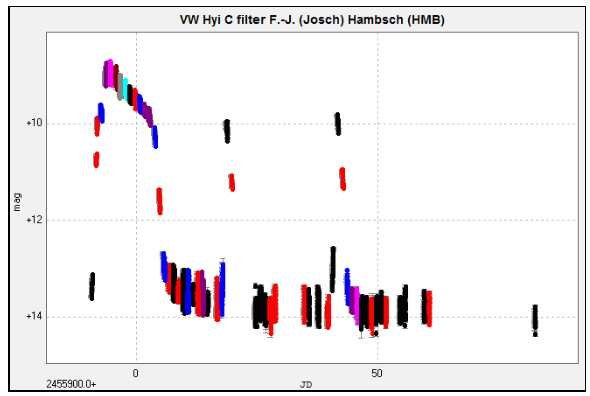

Fig. 6 Observations of VW Hyi during superoutburst and normal outburst.

VW Hyi is a popular cataclysmic variable in the Southern sky. Many studies have been performed about this star; see e.g. AAVSO (2010). During quiescence the star is at magnitude 14.4. Normal outbursts happen on average every 27.3 d and last about 1.4 d. The superoutburst happens on average every 179 d and lasts for about 12.6 d. Fig. 6 shows impressively this behavior of VW Hyi with one superoutburst and two normal outbursts.

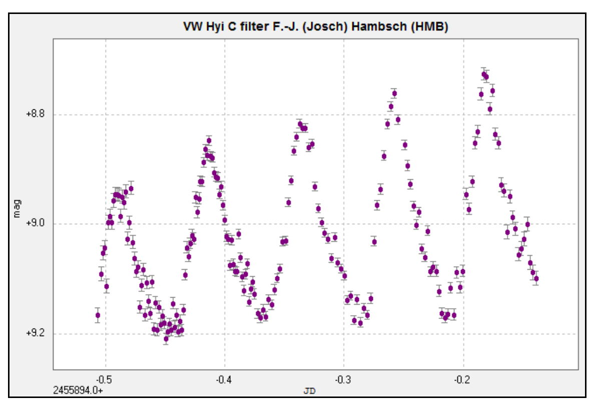

Fig. 7 Observations during one night at the top of the superoutburst.

The star develops strong superhumps during its outburst as can be seen in Fig. 7. The variation of those humps reaches 0.5 magnitudes.

6. Example of an RR Lyr Star: V1820 Ori

This type of variable is named after the prototype, the variable star RR Lyrae in the constellation Lyra. RR Lyr stars are pulsating horizontal branch stars with a mass of around half of our Sun's. Their period is short, typically less than one day.

My interest in observing RR Lyr stars is on one hand due to the short period of those stars. So within one night you can see already quite a change in brightness. On the other hand the stars also show some brightness modulations which is known as the Blazhko effect. Back in 1907, S. Blazhko observed this effect for the first time on the star RW Dra (Smith, 2004). The Blazhko effect is to date not really understood and needs further observational campaigns. Recently due to the Kepler and CoRot satellite missions more insight into this phenomenon has been gained as the satellites can of course observe the stars continuously, which is impossible for Earth-bound observations. Nevertheless observations from Earth are also very valuable as can be seen in many publications on this subject in the astronomical literature. Fig. 8 shows the phase diagram of the RR Lyr star V1820 Ori, which has been observed from Chile over a full season (more than 3 month). It is obvious from the figure that the light curve is not regular, the maximum brightness is changing over more than 0.5 mag. And also the moment of maximum time is changing. So a rather complex light curve is the result. Presently the data are under analysis and the results are intended to be published.

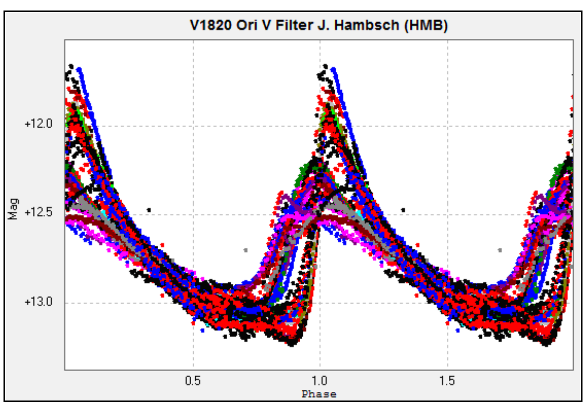

Fig. 8 Light curve of the observations of BW Scl over a period of nearly three month.

7. Conclusion

The remote observatory under pristine skies in the Atacama Desert opens up great 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 given examples show impressively what is possible. Collaborations are searched for in order to contribute to scientific research of common interest.

8. References

AAVSO (2010) "Variable Star of the Month." *http://www.aavso.org/vsots_vwhyi*

de Ponthierre, P. (2010) LesvePhotometry software at *http://www.dppobservatory.net/AstroPrograms/Software4VSObservers.php*

Fridrich, R. (2011). e-mail to cvnet-outburst.

Kato, T. (2011). vsnet-alert e-mail message 13544.

Masi, G. (2011). vsnet-alert e-mail message 13538.

Ohshima, T. (2011). vsnet-alert e-mail message 13543.

Ohshima, T. (2011a) vsnet-alert e-mail message 13799.

Smith, H. A. (2004). *RR Lyrae Stars*. Cambridge University Press. p. 103. ISBN 0521548179.