Intensive Observations of Cataclysmic, RR Lyrae, and High Amplitude δ Scuti (HADS) Variable Stars

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Abstract An intensive observing campaign is ongoing to study cataclysmic, RR Lyrae (with and without Blazhko effect), and High Amplitude δ Scuti (HADS) variable stars. These observations are based on requests and in collaboration with different organisations (CBA, VSNET, GEOS) and individuals. Observations are taken from my private observatories in Belgium, Chile, and through shared use of an observatory belonging to the AAVSOnet in New Mexico. Examples of individual stars intensively followed-up on are: CD Ind and BW Scl, two cataclysmic variables; NU Aur, an RR Lyr star with strong Blazhko effect; and GSC0762-0110, a HADS star. Many publications in different journals including *Astronomy and Astrophysics* have already emerged from this research.

1. Introduction

For the past couple of years I have been changing my interest in amateur astronomy, focussing towards variable star observations. Coming from "pretty picture" imaging and with my scientific background I have now fully dedicated my equipment and efforts towards following intensively short period variable stars like RR Lyr stars, Cataclysmic variables (CV), and High Amplitude Delta Scuti (HADS) stars. My roll-off observatory in my backyard has grown in recent years to house several telescopes dedicated to variable star observations. In Belgium, I observe mainly CV's in collaboration with the Center for Backyard Astrophysics (CBA) based on requests via the CBA e-mail alert list. Also, outburst observations of CV's are performed based on VSNET alerts and data are sent to Kyoto for further analysis. The telescopes used are nowadays a C14, a C11, and a Meade 14-inch, all equipped with SBIG CCD's and photometric filters. Parts of the data shown in Figures 1 and 5 have been taken with those telescopes. As the weather in Belgium is mostly cloudy, I have joined forces with AAVSO and share one of AAVSOnet telescopes (W30) with fellow AAVSOnet observers. With this telescope and the much better weather conditions in New Mexico most of the data from Figures 1 and 2 have been acquired. In addition, since mid-2011 I have found the ultimate observing site in the Atacama Desert in Chile. Since August 2011 a remote telescope (40 cm *f*/6.8 Optimized Dall Kirkham (ODK) from Orion Optics, UK) is operational utilizing an FLI ML16803 CCD with Astrodon photometric filters. The data

shown in Figures 3 and 4 have been acquired remotely. In the following some explanations about the variable type and some examples of observational results acquired at the different sites mentioned above are given.

2. RR Lyr stars

This type of variable star 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. They are thought to have previously shed mass and, consequently, they were once stars with similar or slightly less mass than the Sun, around 0.8 solar mass. RR Lyr stars pulsate in a manner similar to Cepheid and δ Scuti variables, so the mechanism for the pulsation is thought to be similar, but the nature and histories of these stars is thought to be rather different. In contrast to Cepheids, RR Lyr stars are old, relatively low mass, metal-poor so-called "Population II" stars. They are much more common than Cepheids, but also much less luminous. Their period is shorter, typically less than one day.

The RR Lyr stars are conventionally divided into three main types based on the shape of the stars' brightness curves:

1) RRab, the majority type, which display steep rises in brightness;

2) RRc, a type with shorter periods and more sinusoidal variation; and

3) RRd, a rare type of double-mode pulsators.

RRab types are fundamental mode pulsators, RRc types are pulsating in the first overtone, and RRd are a combination of both modes.

My interest in observing RR Lyr stars is on one hand due to the short period of those stars: Within one night you can see already quite a change in brightness. On the other hand the stars also show brightness modulation which is known as the Blazhko effect. 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. Recently, thanks 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 (Kolenberg 2011). Nevertheless, observations from Earth are also very valuable as can be seen in many publications on this subject in the astronomical literature.

Examples of RR Lyr stars showing Blazhko effect are given in Figures 1 and 2. Both NU Aur and VY CrB are RRab types with a rather strong modulation of the light curve due to the Blahzko effect. Both the maximum brightness and the time of maximum are changed.

3. Cataclysmic variables

Cataclysmic variable (CV) stars undergo large brightness increases of several magnitudes which last for a few days and then they drop back to a quiescent state. The stars are novae, dwarf novae, or closely related objects which undergo these outburts in a regular or semiregular way. They are normally interacting binaries of which one star is a white dwarf and the second star is closer to the main sequence. The latter star loses matter in the direction of the white dwarf, usually forming an accretion disk. The repetitive outbursts are most probably due to material from the accretion disk accumulating on the white dwarf and causing, for example, a thermonuclear reaction. CVs are subdivided into several classes, for example, those which have strong magnetic fields are called polars, an example of which is CD Ind.

I came to this sort of object by subscribing to different variable star mailing lists and by my recent participation in the SAS meeting in Big Bear in 2009, where I joined the CBA (Center for Backyard Astronomy) group. There was a meeting adjacent to the SAS meeting in Big Bear, and I met Joe Patterson in person. Since then I have been contributing my observations to the CBA data repository as well as the AAVSO International Database. Also, through T. Kato's VSNET alerts, I get information about interesting CV's in outburst, which can be followed up on.

Some examples of Cataclysmic Variables are given in Figures 3 and 4 (CD Ind and BW Scl). The most recent outburst and the first ever detected was for BW Scl. Due to my remote observatory I could follow this star during the pre-outburst period nearly until the writing of this paper, over a period of more than two months. I just missed the rise to outburst. Figure 4 shows the observed light curve.

4. High Amplitude δ Scuti (HADS) stars

δ Scuti stars exhibit both radial and non-radial luminosity pulsations. Non-radial pulsations are when some parts of the surface move inwards and some outward at the same time. Radial pulsations are a special case, where the star expands and contracts around its equilibrium state by altering the radius to maintain its spherical shape. Throughout their lifetime δ Scuti stars exhibit pulsation when they are situated on the classical Cepheid instability strip. They then move across from the main sequence into the giant branch.

I have been observing this kind of star for a couple of years based on a collaboration with Patrick Wils and the Flemish Association of Variable Stars. This group has an intensive CCD campaign in following up on HADS stars. The list of stars is provided by P. Wils and can be accessed at the following URL:

http://www.vvs.be/werkgroepen/werkgroep-veranderlijke-sterren/over-werkgroep-veranderlijke-sterren/de-werkgroep/hads-0#overlay-context=werkgroepen/werkgroep-veranderlijke-sterren/hads-waarnemingen

Wils collects the data and analyzes them in terms of determining the epoch and period of the star over a longer time span of several years to look for variations in these parameters. Occasionally, multi-periodic stars are also found in the list. They are then more intensely observed by several observers distributed around the globe to get a continuous capture of the light curve and its variations due to multiple periods. Those stars are of course the more interesting ones, as the light curve changes from night to night. An example, the HADS star GSC0762-0110 (Wils *et al.* 2008), is given in Figure 5.

5. Acknowledgements

The Wikipedia online free encyclopaedia is used for the introductory explanations to RR Lyrae, Cataclysmic, and HADS variable stars. I would like to thank Patrick Wils for valuable comments on the manuscript.

References

Kolenberg, K. 2011, arXiv:1108.4987v1 [astro-ph.SR], (http://arxiv.org/abs/1108.4987) and references therein.

Smith, H. A. 2004, *RR Lyrae Stars*, Cambridge Univ. Press, Cambridge, 103.

Wils, P., Rozakis, I., Kleidis, S., Hambsch, F. -J., and Bernhard, K. 2008, *Astron. Astrophys.*, **478**, 865.

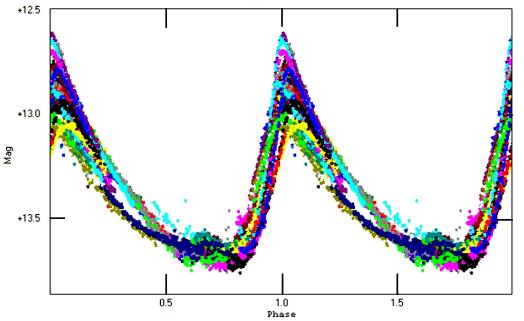

Figure 1. Phase diagram of NU Aur, a RR Lyr star with a strong Blazhko effect, which not only changes the maximum brightness but also the time of maximum. Data were taken from the author's backyard observatory and via the AAVSOnet scope W30 in New Mexico. The colors indicate different nightly runs.

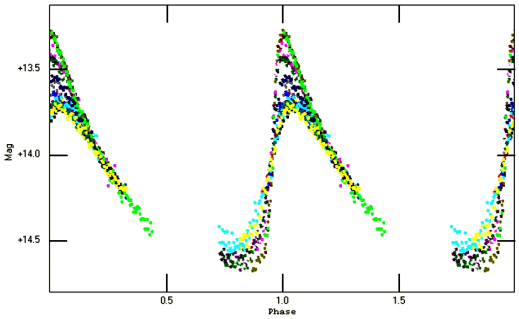

Figure 2. Phase diagram of VY CrB another example of a RR Lyr star showing the Blazhko effect. Data are via the AAVSOnet scope W30 in New Mexico. The colors indicate different nightly runs.

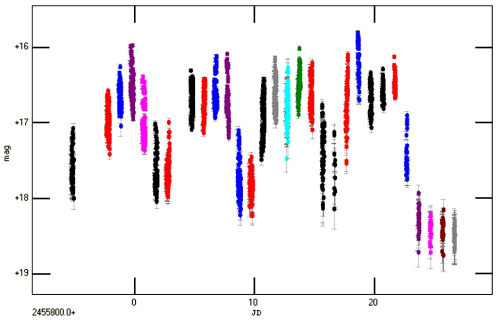

Figure 3. Example of an CV which showed several changes of about 1 mag in brightness during about three weeks of observations. Data were taken remotely from the author's observatory in Chile. The colors indicate different nightly runs.

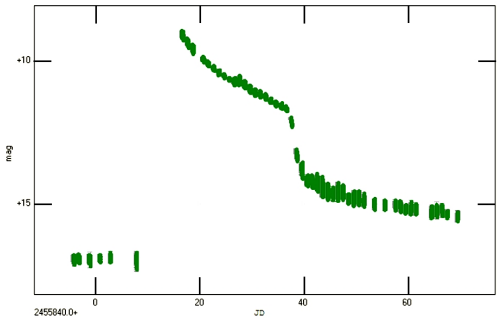

Figure 4. BW Scl showed its first ever detected outburst of more than 6 magnitudes and could be followed in its brightness decrease over more than two month. Also data before the outburst have been acquired. All data were taken remotely from the author's observatory in Chile.

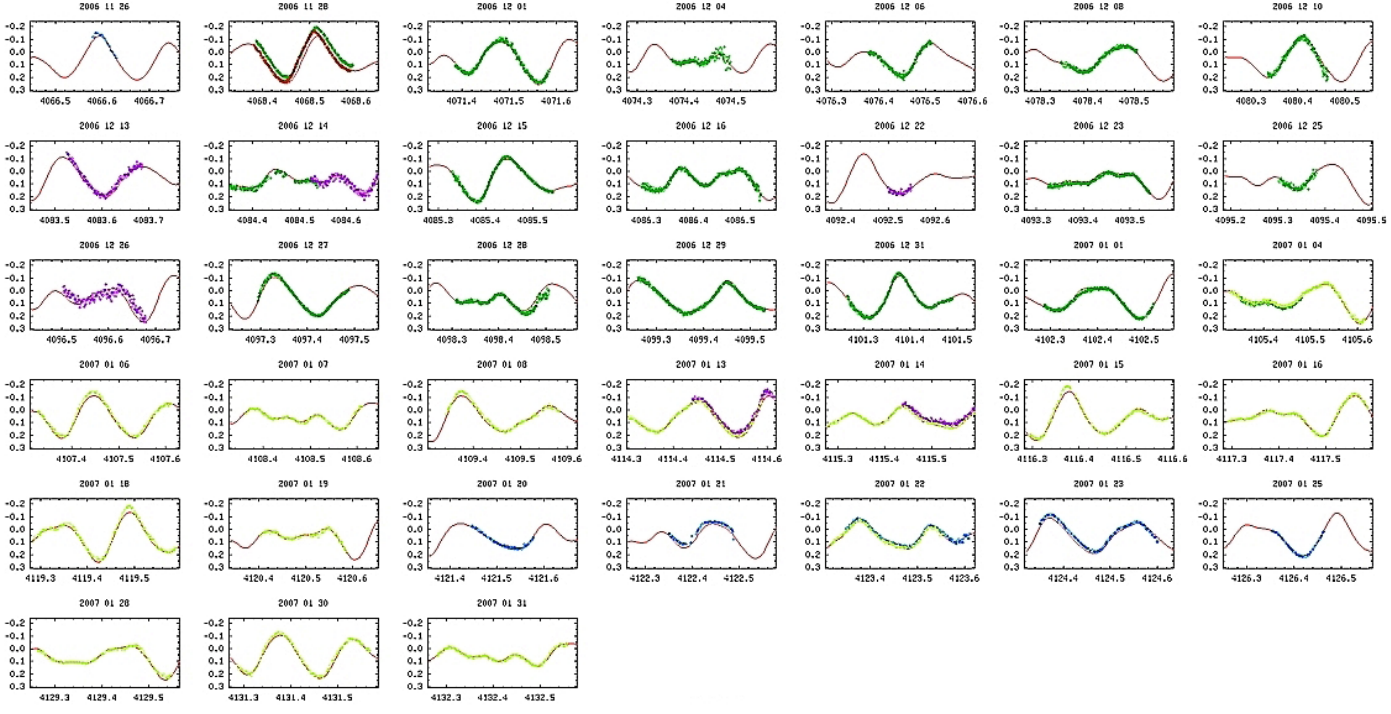

Figure 5. Example of a multi-periodic High Amplitude Delta Scuti (HADS) star, observed during several weeks by several observers. Data were taken from multiple sites by different observers including the author's backyard observatory in Belgium. (Wils *et al.* 2008).