# SOME OBSERVATIONS OF RR LYRAE IN AUGUST/ SEPTEMBER 2005

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## Introduction

The Horace A. Smith book on ‘RR Lyrae Stars’ [1] inspired me to have a close look at this class of variable stars.

As Smith states (p 1):

- *RR Lyrae stars have been tracers of the chemical and dynamical properties of old stellar populations within our own and nearby galaxies*
- *RR Lyrae stars have served as standard candles, indicating the distances to globular clusters, to the centre of the galaxy, and to neighbouring Local Group systems*
- *RR Lyrae stars have served as test objects for theories of the evolution of low mass stars and for theories of stellar pulsation.*

The book asserts that visual observers can still make a contribution to the study of these stars, in a number of ways: visual observers can determine the shape of the light curve of the three classes of RR Lyrae stars (RRab,RRc,RRd); we can determine, with reasonable accuracy, the pulsation period, which is less than a day; and we can help to construct OC diagrams that contain clues to the evolution of these stars and to their internal dynamics. Smith estimates (p6) that more than 20% of all variable stars are of the RR Lyrae class.

An opportunity arose to study the prototype, RR Lyrae itself, which is the brightest of its class. It has a period of 0.56686 days [2], varies between magnitude 7.1 and 8.1, and has a characteristic light curve of the type RRab (see Figure 4).

I observed this star visually from a site on La Palma, the Canary Islands, on 84 occasions between the 12th August 2005 and the 25th August 2005. The site was located at 28 46 N and 17 56 W. The altitude of the site was about 1300 metres above sea level and therefore above the trade winds and the usual layer of clouds. When the moon and cloud were absent, observations took place in class one conditions; there was no light pollution whatsoever, and the atmosphere was stable and dry.

The star was also observed from Edinburgh, in class two conditions, on the evening of 25th September 2005, when 13 observations were made.

The instrument used for these observations was 11x80 binoculars mounted on a tripod. The moon interfered with some observations, and some of the observation runs were cut short by the appearance of clouds. The guidelines that I referred to whilst making the observations was the BAA publication *Observing Guide to Variable Stars* [3].

I used the chart AAVSO 1925+43 (b), which is entitled V1504 Cygni. The comparison stars were those marked 70, 75 and 78, and RR Lyrae and the comparison stars were all in the same binocular field of view. There were some doubts about the accuracy of the magnitude of two of the comparison stars: the gap between 75 and 78 seems to be 0.4

magnitude rather than 0.3.

On La Palma it turned out to be possible to observe seven maxima of RR Lyrae within the period 12/8/05 to 25/8/05. A further maximum was observed in Edinburgh on the evening of 25/9/05.

## The Maxima

The seven maxima observed in La Palma were determined to occur at the following times, where HJD means Heliocentric Julian Date.

| | | |
|---|---|---|
| 4.5UT | on 12/8/05 | (HJD 2453594.6900) |
| 23.75UT | on 14/8/05 | (HJD 2453597.4921) |
| 2.85UT | on 16/8/05 | (HJD 2453598.6212) |
| 4.75UT | on 21/8/05 | (HJD 2453603.7003) |
| 21.45UT | on 22/8/05 | (HJD 2453605.3961) |
| 0.5UT | on 24/8/05 | (HJD 2453606.5232) |
| 3.85UT | on 25/8/05 | (HJD 2453607.6627). |

The Edinburgh maximum occurred at:

| | | |
|---|---|---|
| 22.15UT | on 25/9/05 | (HJD 2453639.4244 ) |

These maxima were determined by actual observation. The times of the maxima are taken to be the times of the brightest observation. The observations were timed to coincide with either a tenth or a twentieth of an hour, and this means that the time of maximum was accurate to plus or minus 6 minutes.

The Heliocentric JD was calculated using coordinnates for RR Lyrae of RA 19.25.27 and Dec. 42.47.04, which were taken from *http://webast.ast.obs-mip.fr/people/leborgne/dbRR/*.

## Light Curves

The three best (most complete) light curves around the maxima are plotted in Figure 1 (14/8/05), Figure 2 (22/8/05) and Figure 3 (24/8/05). The horizontal axis is the Julian date. The light curves show the characteristic shape of RRab variables, with a steep rise to maximum and a less steep decline.

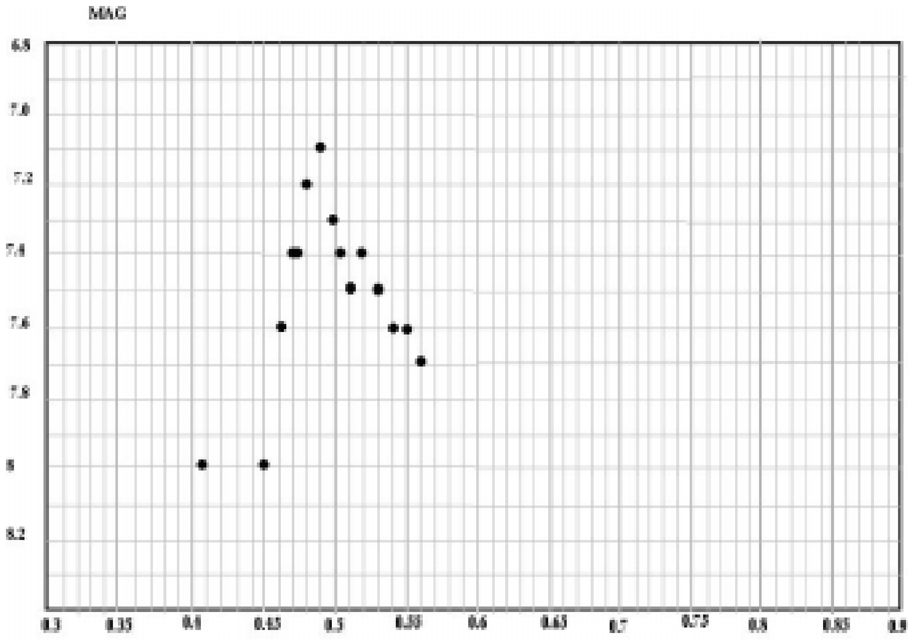


Figure 1. 14th August 2003 JD 3597 Maximum at HJD 3597.4921

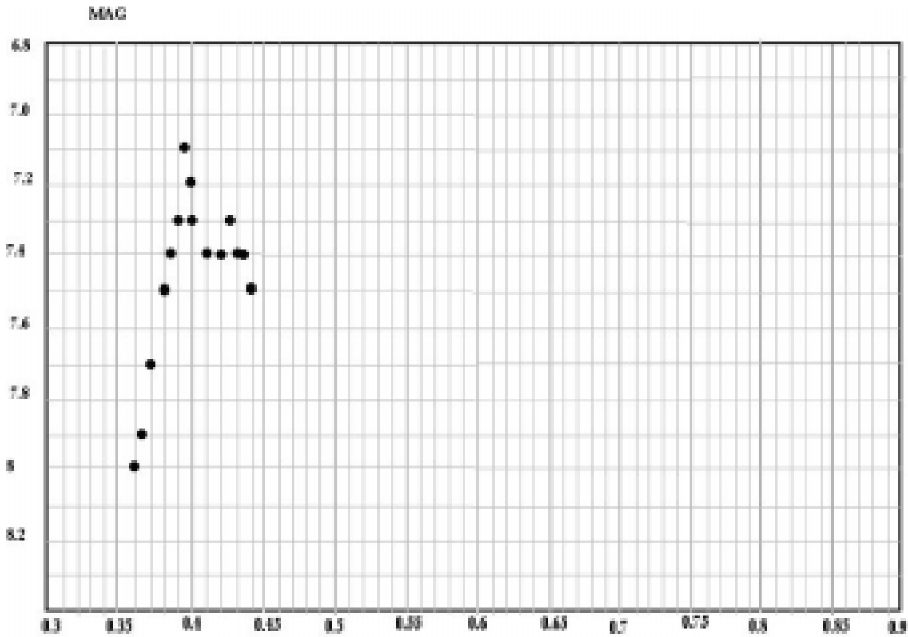


Figure 2 22nd August 2003 JD 3605 - Maximum at HJD 3605.3961

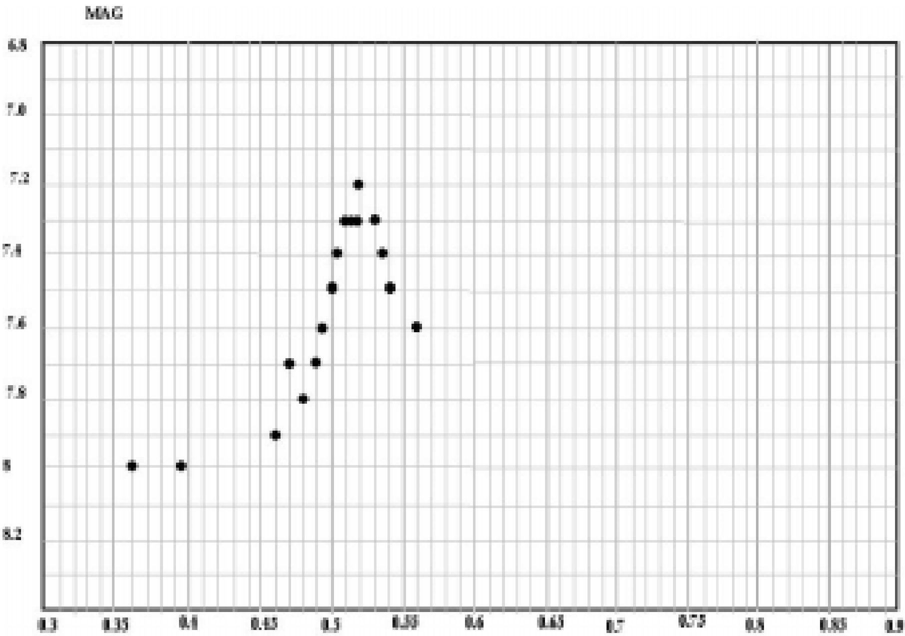


Figure 3. 24th August 2005 JD 3606 - Maximum at HJD 3606.3232

**Shock Wave Phenomena**

Smith (p82 - 88) describes shock wave phenomena which are part of the pulsation process of RR Lyrae stars. The shock waves are manifested by subtle features of the light curve, as seen in the characteristic light curve in Figure 4. Near minimum there is a *bump*, and on the rise to maximum there is a *hump*. The hump coincides with the maximum acceleration of the photosphere and emission of ultraviolet light.

It is considered that there may be a suggestion of a subtle *hump* on the rising light curve of the maxima of the 25/9/05 which is figure 5.

**Period**

The period (from *http://www.astro.uni-bonn.de/~gmaintz/3230tab1.dat*) is 0.56686, and the epoch of maximum is HJD 2452901.4020.

Within the time interval observed in August, 23 maxima occurred. If the time between the first and the seventh maxima observed (2453607.6627-2453594.6900) is divided by 23, then the average period comes to 0.5640. The difference between this period and the predicted period is 4.12 minutes.

The observation in September allowed the estimation of the average period over a much longer time span. Between the first observation on La Palma and the September

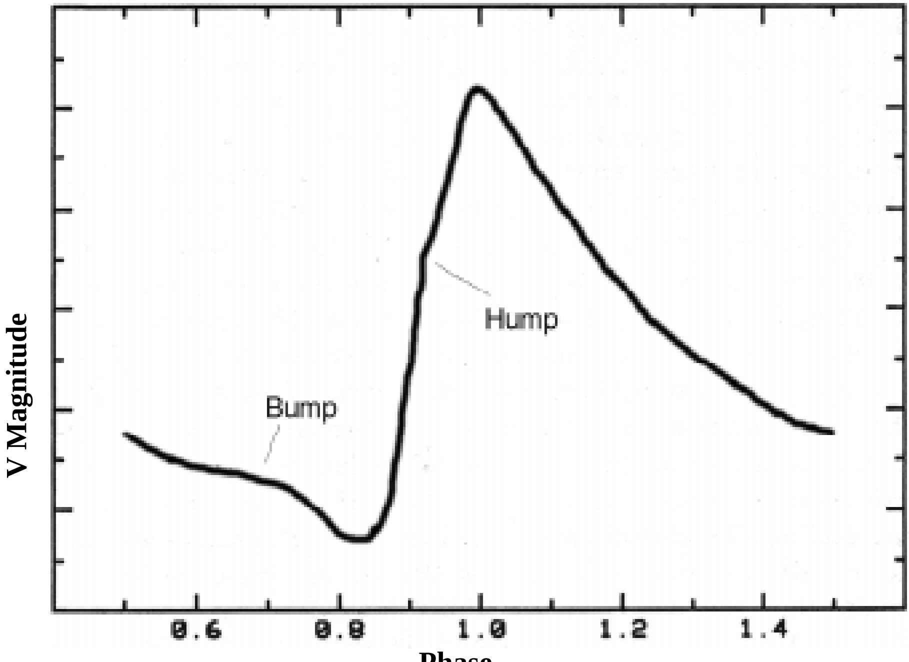


**Figure 4: A Typical Light Curve**

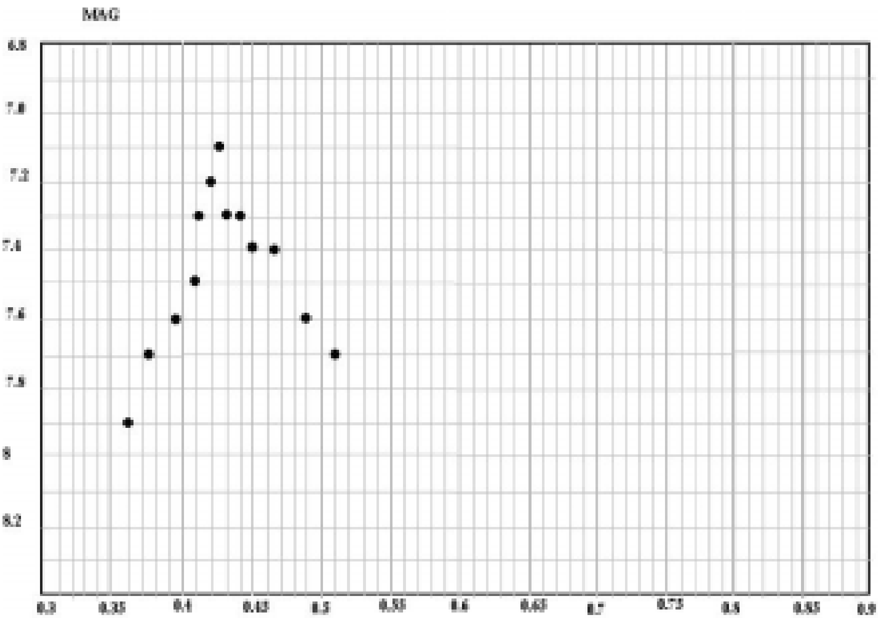


Figure 5.

25-26/9/85 JD 3639 - Maximum at HJD 3639.4284 observation there were 79 pulsations. When the time span is divided by 79 the average period comes to 0.56626, which is a difference of 0.87 of a minute compared with the official period. Between the last observation in La Palma and the September observation there were 56 pulsations. When this time span is divided by 56 the average period comes to 0.56720, which is a difference of 0.4896 of a minute compared with the official period.

These results illustrate that over long enough time spans visual observations can be accurate enough to alert CCD observers to significant changes.

**Observed/Calculated Maxima**

Figure 6 shows an OC graph which is generated from these observations. The horizontal axis is the pulsation number counted from the first one observed on La Palma. The horizontal axis could, however, be defined in HJDs. The horizontal zero line is where predicted maxima should occur. The vertical axis represents the difference between the predicted maximum and the actual maximum defined as a decimal fraction of a day.

The plots of the eight actual maxima are removed from the zero line. The 22nd maximum is significantly removed by about 0.05 of a day or 1.2 hours. This time is well beyond any possible error arising from careful visual observations in good conditions. This diagram illustrates how the period can vary. Smith outlines the explanation for this type of period/cycle variation which is deemed to be *noise*. In other words, the short term variation in cycle period is not related to the long term evolution of the star, but is related to semi-convection events in the outer atmospheres of these large red stars. Despite being labelled as noise there is a glimpse into the dynamics of these low mass stars.

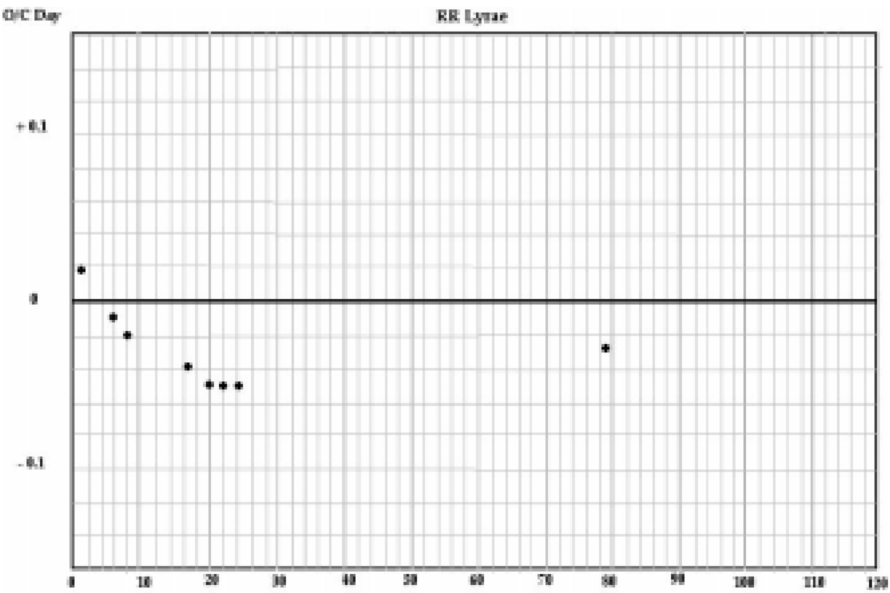


Figure 6. Maxima : August - September

The web site *http://webast.ast.obs-mip.fr/people/leborgne/dbRR/maxRR.htm* presents information about RR Lyrae stars, and, in particular, about RR Lyrae itself. The site displays an OC diagram covering a lengthy period, which is here reproduced as Figure 7. This shows how the period can vary around the standard period.

It can be readily appreciated that the scale of the *noise* variation in period is one that can be picked up by visual observers.

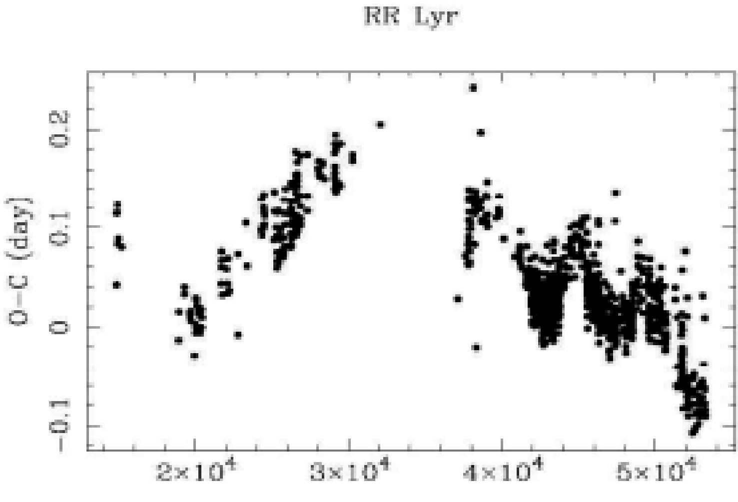


Figure 7

**2004 Blazhko Effect Campaign**

Professionals carried out a year long campaign to observe the Blazhko Effect in a number of RR Lyrae stars. The observations are reported on *http://www.astro.univie.ac.at/~blazhko/RRLyrae2004.html#Figures.* The Blazhko Effect is a secondary pulsation that occurs in some RR Lyrae stars.

Among the stars studied was RR Lyrae itself which has a secondary period of 40.8 days, and the light curves and OC diagrams that are published on the above web pages show that the amplitude of the maximum, the position of maximum and the shape of the light curve vary over the Blazhko period. The maximum, within the 40.8 day period, appears to vary over about 0.1 of the phase which is equal to 0.0567 days or 1.36 hours. This variation may explain the results of my OC diagram of the maxima observed in August/September 2005.
The results of this campaign suggest that it may not be correct, in the short term, to estimate the period as the time between two maxima. The results suggest that the time of maximum can vary within a cycle without the period of the cycle being affected.

The website also reports that RR Lyrae shows a cycle in its Blazhko Effect of about 4 years, at the end of which the strength of the modulation suddenly decreases, and a phase shift of about 10 days occurs in the Blazhko cycle. This phenomenon is still unexplained, though it has been used as an argument for the magnetic models of the Blazhko Effect..

**Conclusion**

The observations in August/ September 2005 illustrate the useful work that can still be done by visual observers. Good estimates of the mean period can be made, and reasonable OC diagrams can be constructed from these. It also appears that some monitoring of the Blazhko Effect can be attempted, and that the results can be significantly refined if the observing campaign can be carried out over a longer period by a team of observers [4].

The argument for ongoing observations is well put by Horace Smith in the AAVSO RR Lyrae Bulletin Number 2 of March 2002 [5]. He states that long terms changes in the primary periods of these stars can give clues about the ways in which all stars age.

A good summary of the RR Lyrae class of stars and the observational challenges can be found in the *AAVSO Variable Star of the Month for August 2002* which was an RR Lyrae star called XZ Cygni [6].

Monitoring such stars is a challenge for visual observers. To get a good light curve of a maximum one has to carry out observations over a period of at least three hours, with one before maximum and two hours after. Before devoting such time one has to work out when the maximum may actually occur, and bear in mind that the time of maximum may be substantially different from the predicted time. On La Palma, once I became aware of the vagaries of the maxima, I made a check on the magnitude two hours before the predicted maximum and at quarter of an hour intervals thereafter, until I could pick up the upward movement when the star brightened to 7.8. Thereafter the star was estimated at ten/ twelve minute intervals until an hour after maximum, when an estimation every fifteen minutes became sufficient.

**References**


1 RR Lyrae Stars, Horace A Smith, 1995, Cambridge University Press
2 http://www.astro.uni-bonn.de/~gmaintz/3230tab1.dat
3 Observing Guide to Variable Stars, BAA, 2005
4 The AAVSO Observing Program on RR Lyrae Stars http:// www.aavso.org/ observing/ programs/rrlyrae/
5 AAVSO RR Lyrae Bulletin N0 2 March 2002.
6 AAVSO Variable Star of the Month, August 2002 - XZ Cygni.