THE LIGHT CURVE OF THE R CORONAE BOREALIS STAR NSV 6708 (V854 CENTAURI) AND THE ACCURACY OF VISUAL ESTIMATES

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Abstract

The R Coronae Borealis star NSV 6708 (V854 Centauri) has been monitored by visual observers for over four years and photoelectrically for two years. The comparison of the visual estimates and the photoelectric data offers some insight into the potential accuracy of visual light curves. We also make some suggestions about the selection of comparison sequences and sources of error in visual estimates.

1. Introduction

NSV 6708 (V854 Centauri) has attracted a great deal of attention since it was first suspected of being an R Coronae Borealis (RCrB) star by McNaught (1988). NSV 6708 has been studied by Kilkenny and Marang (1989) and Lawson and Cottrell (1989) who showed that it exhibited many of the usual characteristics of RCrB stars, e.g., low amplitude variations at maximum, large amplitude declines, and a circumstellar shell, but that it had unusually strong hydrogen lines compared to other RCrB stars. The star has also been an ideal target for amateur variable star observers due to its brightness at maximum (V = 7) and its frequent declines.

2. Observations

Observers of the Variable Star Section of the Royal Astronomical Society of New Zealand (VSSRASNZ) have monitored NSV 6708 since July 1986. All of these estimates obtained prior to March 1990 (with the exception of a few erroneous values) and some additional estimates from *IAU Circulars*, are shown in Figure 1. The visual light curve for NSV 6708 extends the long series of such light curves for RCrB stars published by Bateson (1975, 1978) and Lawson, Cottrell, and Bateson (1988, 1989). The estimates will be published in a future*Circular* of the VSSRASNZ.

Offset by four magnitudes from the visual estimates are photoelectric V magnitudes obtained at Mount John University Observatory (MJUO) during 1988 (Lawson and Cottrell 1989) and 1989 (Lawson 1990) as part of an extensive program to study the Hydrogen-deficient Carbon (HdC) and RCrB stars. The V data were obtained with the

two 0.6-m reflectors at MJUO and automated single-channel photometers. The observations were obtained differentially with respect to nearby comparison stars and then tied into the standard system. The light curve shows three declines and low amplitude (< 1 magnitude) variations at maximum.

3. Discussion

There is a general impression that, unless the variability of a star exceeds several tenths of a magnitude, light curves derived from visual estimates are not capable of revealing lower amplitude variations or, if such variations are apparent, that they should be regarded with some suspicion. A comparison between the parts of the light curve in Figure 1, that have been observed both visually and photoelectrically, indicates quite clearly that there is excellent agreement between the features present in both data sets, in particular the low amplitude variations seen when the star is not in decline.

To further demonstrate the similarity of these data sets, we show a part of the light curve (the data obtained during 1989) on an enhanced scale in Figure 2a. The data sets are (from top to bottom, respectively) the entire VSSRASNZ estimates, the estimates of P. Williams (which are also included in the VSSRASNZ data set) and the MJUO V photometry. A comparison of the VSSRASNZ and the MJUO data shows that features with amplitudes as little as 0.1 magnitude are discernible in the visual light curve although there is sometimes disagreement between observers, e.g., near JD 2447580. The estimates of Williams show that an experienced observer is capable of resolving such features in the light curve independently (it is normal practice to combine or average all visual estimates in 5 or 10 d means). In Figure 2b we show amplitude spectra for observations obtained for JD 2447570 - 2447780 for the three data sets. The spectra were calculated using the Lomb-Scargle Fourier technique for non-equally spaced data (Scargle 1982; Press and Teukolsky 1988 for a Fortran code). Note that, although the amplitudes of the peak features are weakened in the spectra of the visual data sets, there is a general correspondence between the VSSRASNZ and MJUO spectra. A detailed analysis of the MJUO photometry of NSV 6708 suggested that the star may have 3 periods of ~ 45 d, 70 d, and 110 d respectively (Lawson 1990). An analysis of the VSSRASNZ data indicates that similar periods can be obtained from these data.

Several factors account for the high-quality estimates for this star:

(i) The variable and its comparison sequence are bright.

(ii) The comparison sequence is photoelectrically determined. The lack of accurate magnitudes remains a major source of error in many fields.

(iii) The magnitudes and colors of several of the comparison stars are similar to the variable. Small ΔV and color terms minimize extrapolation errors when comparing the brightness of the variable to its comparison stars.

(iv) The comparison stars for NSV 6708 are close to the variable.

Astronomers would do well to consider (ii), (iii), and (iv) when requesting visual observations of variable stars.

Even for the NSV 6708 field, the influence of different observers upon the scatter in the VSSRASNZ light curve may be significant. Note that the scatter in the VSSRASNZ data set is often greater than that of Williams' estimates. Preliminary calculations for other variable stars indicate that differing zero-point magnitudes for individual observers can have a significant effect on the light curve and that the agreement between photometric and visual data can be better than 0.05 magnitude if these offsets are removed. To enable such offsets to be made, the name of the observer contributing the estimates must be preserved. Higher accuracy visual light curves may be useful for the long term

monitoring of the periodic behavior in low amplitude variables.

4. Conclusions

The light curve for NSV 6708 indicates that visual estimates can resolve features at the 0.1 magnitude level. The analysis of visual estimates for this star compares favorably with the analysis of photoelectric data. We suggest that an optimized comparison sequence is essential to obtain such high quality results. We also indicate that differing zero-point magnitudes for individual observers may be a significant source of scatter in visual light curves.

5. Acknowledgements

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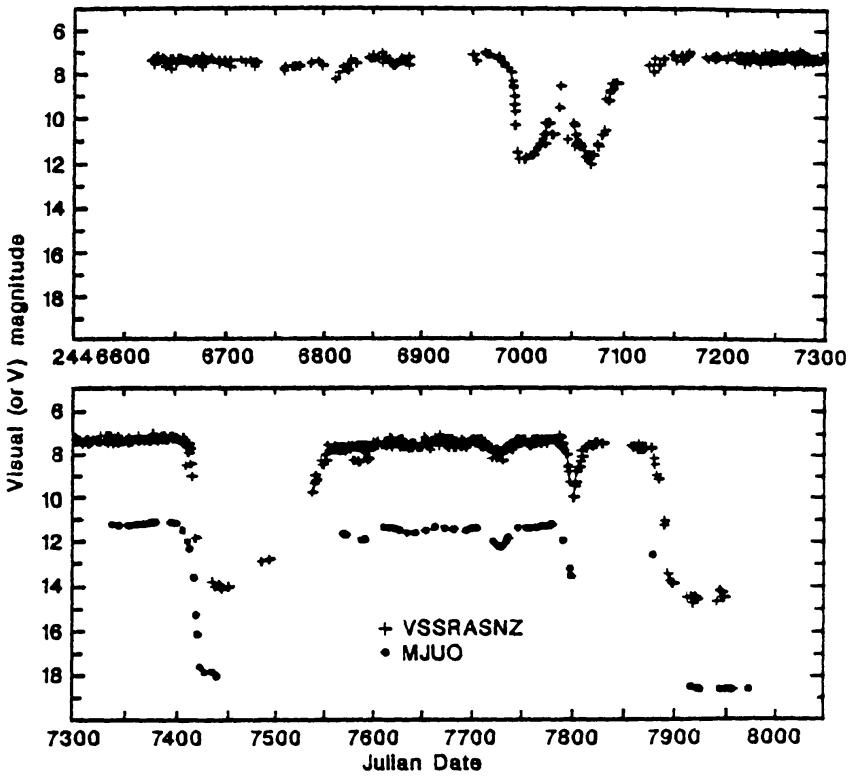

Figure 1. Light curve of the R Coronae Borealis star NSV 6708 (V854 Cen). The pluses are visual estimates mainly from observers of the Variable Star Section of the Royal Astronomical Society of New Zealand (VSSRASNZ). The filled circles are photoelectric V magnitudes obtained at Mount John University Observatory (MJUO) offset by four magnitudes with respect to the visual estimates.

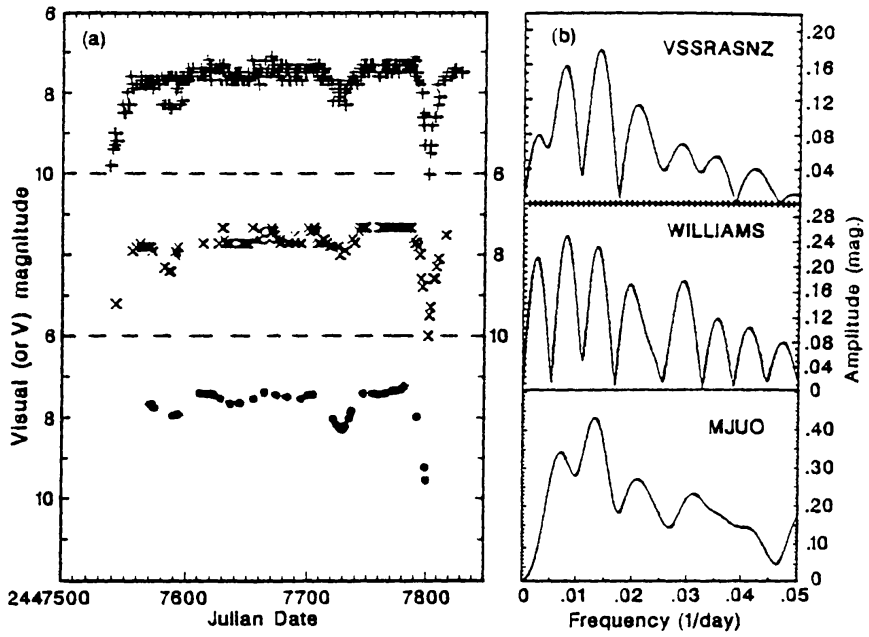

Figure 2. (a) Light curves for NSV 6708 for JD 2447540 - 2447830. The data are (from top to bottom) the VSSRASNZ estimates, the estimates of P. Williams, and the MJUO V photometry. (b) Amplitude spectra versus frequency for these three data sets.