A W Roberts: The observations (Paper 2)*

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Introduction

Fraser (2004) described A W Roberts the observer. In this paper we look at his observations and put his contribution to variable star astronomy into proper perspective. To date we have captured all of Roberts' documented observations electronically and are busy with the second phase of the program, processing these for submission to the AAVSO database.

Roberts himself refers to having observed 105 stars (Roberts 1906), though several of these represent only a handful of observations. We have processed observations on 99 stars totalling some 70 000 individual magnitude estimates. The breakdown of these 99 stars by type is shown in Table 1.

Roberts concentrated on variable stars generally south of declination –30°, the most northerly object being the long period variable RZ Sco at declination –23°. His first observation was of the classic δ Cepheid variable ℓ Carinae on 1891 April 7. The star with the largest number of observations is the eclipsing RR Cen with 2289 observations. Roberts himself discovered the variability of this star.

Roberts' observing methodology

Fraser (2004) and van Zyl (2003) have discussed Roberts' instrumentation. In summary this was:

- 1-inch theodolite by Troughton and Simms,
- 2-inch equatorial by T Cooke and Sons, with prism at the front of the objective, and lowest power giving a field of nearly 3°, and a
- 3¼-inch Ross telescope for observing fainter variables.

Roberts began observing in 1891, when only 35 variable stars were catalogued south of declination –30° (Roberts 1891). In those days suitable variable star charts were not available and Roberts had to make his own. Quoting from his own method (Roberts 1891)

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he would plot the positions of all stars in the vicinity of a known variable star on a sheet of plain paper, using the positions given in the *Cape Photometric Durchmusterung*. The next step was to 'fix upon certain stars as starting points from which to give relative magnitudes to all the other stars in the zone'. He generally used Gould's *Uranometria Argentina* for his early magnitudes, but later used Harvard College Observatory magnitudes where these became available. In 1912, he acquired on loan a 4-inch Harvard meridian photometer, which he used to determine accurate comparison star magnitudes, especially for observing Algol variables (Roberts 1913). A typical chart he constructed is shown in Figure 1, for the variable Z Car. Table 2 compares his magnitudes for comparison stars with values from the current AAVSO chart and from *Guide 6*. These would indicate he estimated Z Car about a magnitude brighter than would be the case using today's accepted magnitudes for the same comparison stars.

Table 1. Types of variable stars observed by A W Roberts

Type	No. of stars
Long period	55
Semi regular	10
Cepheids	20
Eclipsing	7
Irregular	3
R Cor Bor	1
RR Lyrae	1
Novae	1
T Tri Austr	1

Figure 1. Roberts' chart for Z Car

Table 2. Magnitudes of comparison stars for Z Car

Star	Roberts	Guide 6	AAVSO
A	8.90	9.6	9.1
α 2025	9.50	10.4	
β 2018	9.28	10.2	10.2
1	10.28	11.3	
1a	10.59	11.5	
2 2032	10.52	11.2	
3	10.46	11.4	11.4
7	10.82	12.1	11.8
9	10.98	12.1	
10	11.21	12.8	12.6

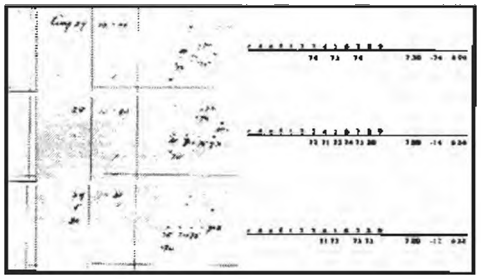

Figure 2. Raw observations of R Cen (left) and corresponding logbook entry (right).

Using these charts as a base, Roberts would now observe the variable in question. He would make a rough sketch at the eyepiece, estimating the magnitude of the variable, but also determining the brightness of other nearby stars in the field. An example for the variable R Cen is shown in Figure 2. In this way he could determine if other stars in the vicinity were themselves variable or not, and whether they could later be used as comparison stars. Each measure was the mean of two observations, one direct and the other reverse, to eliminate the errors of position angle. Also, each measure was based on averaging the observation of around five comparison stars (Roberts 1896a). This leads us to two probable misconceptions surrounding Roberts' observations.

Firstly, that Roberts observed with an accuracy of 0.01 magnitude. In fact Roberts himself concluded that 'few observers can discern with absolute precision 1/10 of a magnitude' (Roberts 1891). Further, he derived a mean error of 0.04 for his own observations of Algol variables on a single night (Roberts 1896b). Thus his accuracy was probably somewhere between 0.04 and 0.1 magnitude, and his reporting of all observations to 0.01 magnitude was simply the result of averaging several determinations and failing to round the result.

Secondly that Roberts made over 250 000 observations. Our capture of his observations indicate he made around 70 000 observations. Each of these was the result of up to five determinations using different comparison stars and averaging the result. In fact this process is exactly the same as would be expected of any accomplished observer today, never relying on an estimate made with a single pair of comparison stars, but with several determinations constituting one observation. This former statement led others later to conclude that Roberts made substantially more observations than he did.

Following the night's rough sketches, Roberts would transfer each sketch neatly onto logs for each star, recording the variable and brightness of nearby stars on the first night in black pencil, the second night with blue pencil, the third night with black ink and the fourth night with red ink. After four nights the process would be repeated on a new sheet. After four or five sheets were completed Roberts would determine whether any of the nearby stars showed variability. A typical observing record is shown in Figure 2. He continued to observe in this way until 1922, when, apart from κ Pavonis, he ceased to observe due to work commitments (Roberts 1923). He wrote:

> 'During the year 1922 work has been interrupted at this observatory. The Director was called upon by the Union Government to take over the post of Senior Native Commissioner for South Africa. The delicate conditions of many of the native questions and difficulties made it impossible for the Director to give any part of his time to astronomical work'.

After 31 years, Roberts' contribution to variable star observing had virtually ended.

Processing Roberts' observations

It would appear that all his observations, and the monographs of each star he prepared in order to prepare a book on southern variable stars, remained unpublished, and were stored at Boyden until 2003. Some years earlier, Danie Overbeek had proposed a program to reduce the observations but found the task too daunting. The late Dr Janet Mattei again proposed a program during her visit to South Africa in December 2002. As a result a team, comprising the authors and the AAVSO, was set up to digitize Roberts' observations and make these available to the astronomical community.

Firstly we catalogued the contents of the four cupboards at Boyden found to contain Roberts' documents. These consisted of around 140 packets wrapped in brown paper, which when stacked on top of each other would have formed a pile four metres high. By going through each pack we were able to extract the relevant information required to capture Roberts' observations, which were entered into a spreadsheet for each star. A validation file was set up to list each star, its AAVSO designation, and to control the input of the observations. The file kept a running total of the observations captured.

The process was first to enter all the observations which had been summarised, in a handwriting other than his own, on sheets in each pack. These summaries were probably prepared by his wife, or perhaps students. We then checked this data for errors by referring to his original observations, and added any observations recorded by Roberts in the last months after these summaries had been prepared. We have just completed this process and are preparing to format the captured data into AAVSO readable files.

Some preliminary results

Reference to Table 3 shows A W Roberts made the third highest total of South African variable star observations. Also, Roberts' observations are earlier than any other South African observers presently in the AAVSO database. J F Skjellerup observed between 1915 and 1932 and Arthur Long from 1917 to 1927. Hence A W Roberts' observing period from 1891 to 1922 provides important earlier observations, and a useful overlap with others, for many variable stars. Table 4 shows the extensions to the AAVSO data for some stars. Analysis of this data will enable us to study fundamental changes to some stars periods and variation modes.

As an example, Ramoshebi et al. (2004) have used the preliminary data to analyse the behaviour of the long period variable R Cen. They added around 1 000 observations made between 1891 and 1918 by Roberts to around 13 000 observations made from 1918 to 2000. Applying Fourier analysis to obtain a power spectrum and wavelet analysis to study the time dependence of period and amplitude, they were able to extend the decline in period and amplitude as found

Table 3. Most prolific South African variable star observers

Observer	No. of observations
M D Overbeek	287 150
R P de Kock	160 777
A W Roberts	~70 000
L Monard (to date)	29 000

by Hawkins et al. (2000) and to show that, in addition, there is a sharp increase in amplitude in the earlier observations made by Roberts. These findings surely indicate that much more remains to be discovered from a detailed analysis of Roberts' additional observations on other stars.

In conclusion, the team continues to process the observations left behind by A W Roberts. We are well on track to complete the data submissions to AAVSO by early 2005, in line with the initial two-year estimate, and to fulfil the conditions of the monetary grant, generously made available by the American Astronomical Society to aid in the completion of this important project.

Table 4. Some examples of extensions to AAVSO data

Star	Earliest AAVSO (JD)	Earliest Roberts (JD)	Extension (days)
L² Pup§	2419816	2411839	7977
R Car#	2417357	2411856	5501
R Cen#	2421608	2411972	9636
R Dor§	2421685	2411861	9824
T Cen§	2419215	2413047	6168
U CrA#	2443257	2414613	28644

Key: Variable type § = semi regular, # = Mira

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