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VARIABLE STAR SECTION

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BH CRUCIS---PHOTOELECTRIC OBSERVATIONS

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SUMMARY: Photo-electric observations of the red variable BH Cru, discovered by Welch in 1969, are presented. A period and epoch are given. BH Cru is classified as one of the small group of R cen-like variables within the Mira Cet type stars.

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INTRODUCTION: Advice of the discovery of a new variable star in Crux was given to the Auckland Observatory by Welch in September 1969. During the interval 1969 October 11 to 1972 February 9, one hundred photo-electric observations were made. All measures have been made with the Auckland Observatory's 50cm Cassegrain reflector, using an EMI 9502 S/A photo-multiplier and standard UBY filters.

Some earlier results were published in Circular 151 using provisional values for comparison stars and provisional extinction and transformation co-efficients. These have now been determined and final values are published herein. The position of the variable was given in Circular 151 as:-

(1900)	12^h	11.1^m	-55°	43'
(1950)	12	13.5	-56	01.9

OBSERVATIONS: All measures were made using differential techniques. The standard stars are listed in Table 1, and the values shown were established in Auckland using standards from Royal Observatory Bulletin 64.

TABLE 1.

	mV	B-V	U-B
CPD -55° 4940 (73A)	7.28	+1.32	+1.35
-55 4926 (83D)	8.17	+0.32	+0.15

The photo-electric observations are listed in Table 2. The values for mV and B-V are expected to be accurate to ± 0.02, but the U-B values are less accurate and range from ± 0.10, where two decimals are given, to ± 0.5 in the case of single decimals. Very doubtful results are indicated by :.

Dr. Richter, Sonneberg Observatory, has kindly supplied measures by Miss Gebner from plates taken in South West Africa in 1937 and 1951.

A period of 420 days was derived from the photo-electric observations. Figure 1 shows a composite light curve covering slightly more than two cycles. The amplitude is about 2.7 magnitudes in the V band, 3.7 in B and possibly 5.0 in ultra-violet.

The repetition of the two cycles is fairly good. Colour changes are as would be expected, except for the U-B curve, which shows a sharp increase of one magnitude in intensity on the rise to the primary maximum. Since the star is relatively faint in ultra-violet most of the time there is a large scatter in this colour but there is no doubt that this feature is real.

A preliminary analysis by Bateson suggested a period of 217 days. The photo-electric observations, particularly the B-V colour curve, reveal that this star is similar to R Cen in that it exhibits a double maximum, and that the true period is near 420 days.

PERIOD; The base-line of the photo-electric observations is very short. We have endeavoured to improve this by using the photographic observations from South West Africa. These are shown in Figures 2a and 2b, where they are plotted to the same scale and using the same phases as Figure 1.

Three film types have been used and presumably no extinction corrections have been applied. Due to the extreme redness of the variable the lack of corrections may introduce errors of up to several tenths of a magnitude. At first glance the figures appear chaotic and discouraging, but by using the known intervals between the various features of the light curve it appears that a valid interpretation can be made, especially in the case of the 1951 observations.

The 1937 observations (Figure 2a) indicate an initial period of invisibility, followed by a slow rise. After a gap in the observations, the star appears once again at the same brightness, still rising. These are probably the rising branches of the two maxima, considerably suppressed. It is possible that the curve reached a peak on JD 2,428,910, although succeeding observations are discordant.

In 1951 (Figure 2b) the star appeared at first to be rising, reaching a peak on JD 2,434,350 at 9.5pg, and then subsequently falling to 13.3pg. These values are very similar to the photoelectric blue magnitudes, which one would expect them to resemble. The long decline is similar to the fading after primary maximum. Due to the different response of the panchromatic film, observations on this should be ignored.

From all the observations Table 3 has been prepared. In the last two columns we have indicated the period change required for an increase or decrease of one cycle in each interval. These values seem improbable.

TABLE 3.

TOTAL INTERVAL	DAYS	CYCLES.	PERIOD	+1 CYCLE	-1
JD 2,428,910-2,434,350	5440	13	419	389	453
2,434,350-2,440,677	6327	15	422	395	452
2,440,677-2,441,097	420	1	420	-	-

It is concluded that the period and epoch of BH Crucis is:-

Epoch (Secondary Min) 2,440,827 $\pm$ $420^{d}.25$

CLASSIFICATION: We have compared BH Cru with the two well studied stars, R Cen and R Nor.

The phase and amplitude relationships are shown numerically in Tables 4-6. Figure 3 compares representative cycles of the three stars reduced to a common period and amplitude.

TABLE 4.

PHASE RELATIONSHIPS OF MAXIMA & MINIMA.

	Period	Min 1	Max 1	Min 11	Max 11
BH Cru	420^{d}	0.00	0.22	0.40	0.54
R Cen (GCVS)	548	0.00	0.23	0.47	0.64
R Cen (VSS)		0.00	0.26	0.44	0.59
R Nor (GCVS)	490	0.00	0.24	0.41	0.56
R Nor (VSS)		0.00	0.22	0.37	0.53

TABLE 5.

AMPLITUDE RELATIONSHIPS OF MAXIMA & MINIMA

AS A PERCENTAGE OF TOTAL LIGHT CHANGE.

	Min 1	Max 1	Min 11	Max 11
BH Cru	100	15	27	0
R Cen (GCVS)	100	0	47	4
R Cen (VSS)	100	3	47	0
R Nor (GCVS)	100	17	41	0
R Nor (VSS)	100	19	45	0

TABLE 6.

MAGNITUDES OF MAXIMA & MINIMA.

	Min 1	Max 1	Min 11	Max 11
BH Cru	10.0 ?	7.6	8.0	7.2
R Cen (GCVS)	11.1	5.8	8.3	6.0
R Cen (Mean VSS)	10.96	6.13	8.33	5.98
R Nor (GCVS)	13.2	8.2	9.7	7.2
R Nor (Mean VSS)	13.5	8.8	10.4	7.7

The phase relationships are very similar, as also are the light curves, and it is probable that these are very similar stars at slightly different points of their evolution. This is possibly supported by the photo-electric colours; +2.5 for BH Cru at maximum; +1.9 for R Cen. There is no photo-electric colour available for R Nor.

In preparing the above tables it is noticeable that there is some disagreement between the information obtained from the General Catalogue of Variable Stars and that derived from a summary of VSS observations as published in the Circulars. Both sets of values have been included.

R Cen has been investigated by a number of researchers. A selection of periods found are shown below:-

SOURCE	PERIOD d	REMARKS
H.A. 55, 1 (1907)	568.2	
H.A. 79 (1928)	564.3	From all obs. to Jan. 1, 1928
Studies of Long Period Variables, Campbell(1955)	542.2	For interval 1921-1949
NZVSS, MEMOIR No.1	543.4	For interval 1927-1940
Prager Catalogue (1933)	551.4	
Schneller " (1939)	544.6	
HA 115, 4	540.2	Milton Bureau Survey
GCVS 2, 1958	546.6	
GCVS 3, 1970	548.0	From 1918

It is difficult to state whether the above values reaåly represent a slowly changing period with a sudden shortening before 1918 because of the different nature of the material from which the respective periods were derived. It does indicate, however, the need to observe stars of this type for several decades. All observers are asked to pay close attention to BH Cru by the VSS Director.

CONCLUSIONS: BH Cru appears to be a member of the small sub-class of Mira Cet type variables having double maxima and minima, typified by R Cen. The light variations of BH Cru are fairly repetitive at present but there are grounds for believing that the amplitude may vary considerably over many years.

There are under a dozen stars of this sub-class known and three of these reach seventh magnitude or brighter at maximum. This appears disproportionate and it is possible that many of these stars are either undiscovered or misclassified. Should some of these resemble BH Cru in colour or amplitude, then it is likely that some are included amongst the Semi-Regular and Long Period stars in the various catalogues.

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REFERENCES.

Bateson, F.M. 1970 VSS, RASNZ, Circular 151.
Kukarkin, B.V. et al 1969 GCVS. USSR Academy of Sciences, Moscow.

TABLE 2.

PHOTOELECTRIC OBSERVATIONS.

J.D.	mV	B-V	U-B	J.D.	mV	B-V	U-B	J.D.	mV	B-V	U-B
2,440,000+				2,441,000+				2,441,000+			
505.8	8.54	+2.81	+1.9::	009.1	7.89	+2.61	+3.5 :	155.9	7.97	+2.84	+2.51
541.2	7.58	2.75	2.4:	014.0	7.88	2.58	3.3 :	163.0	8.05	3.01	2.11
555.1	7.69	2.64	3.5:	016.1	7.93	2.59	3.2	169.8	8.15	2.87	2.20
561.1	7.77	2.67	3.4:	018.0	7.92	2.59	3.3	175.8	8.20	2.95	2.45
562.1	7.71	2.63	3.7:	025.0	7.96	2.61	3.1	180.8	8.28	2.97	2.53
602.0	7.97	2.63	2.6:	027.0	7.96	2.62	2.8	183.9	8.30	3.08	2.49
645.0	7.90	2.62	...	029.1	7.98	2.62	3.1	197.8	8.51	3.13	...
648.0	7.78	2.62	...	030.0	7.99	2.61	3.0	209.8	8.65	3.20	2.91
654.0	7.68	2.55	...	033.9	7.99	2.60	2.6	211.8	8.69	3.18	2.85
665.9	7.33	2.48	...	037.1	7.99	2.65	3.2	217.8	8.71	3.36	...
666.0	7.33	2.51	...	040.9	8.03	2.64	3.0	224.8	8.86	3.45	...
668.9	7.33	2.42	...	047.0	8.00	2.63	2.8	225.8	8.85	3.44	...
681.8	7.24	2.52	+2.10	049.0	7.99	2.64	3.1	258.1	9.24	3.42	...
683.0	7.26	2.49	2.27	063.8	7.77	2.65	3.2	290.1	9.40	3.44	...
688.9	7.29	2.50	2.22	067.0	7.74	2.58	2.78	296.0	9.38	3.53	+3.1 ::
692.9	7.30	2.53	2.28					303.1	9.30	3.43	...
694.0	7.30	2.52	2.33	070.0	7.67	2.54	2.67	327.1	8.79	3.17	...
697.0	7.32	2.52	2.19	076.9	7.46	2.49	2.38	341.1	8.59	2.96	+2.9 :
701.1	7.32	2.58	2.30	082.1	7.33	2.51	1.99	342.0	8.52	2.97	2.4 :
709.9	7.46	2.60	2.17	068.0	7.30	2.50	2.05	349.0	8.40	2.98	1.9 ::
717.8	7.57	2.64	2.35	089.8	7.30	2.48	2.09	350.9	8.37	2.99	3.1 :
721.9	7.66	2.66	2.61	092.0	7.29	2.52	2.05	353.0	8.33	2.93	...
733.9	7.80	2.69	2.51	093.0	7.26	2.50	2.10	357.0	8.29	2.95	+3.4 :
746.8	8.00	2.79	2.7 :	095.8	7.26	2.50	2.01				
758.1	8.16	2.90	2.4 :	098.0	7.29	2.52	2.02				
775.8	8.48	2.96	3.1 :	100.0	7.34	2.54	2.33				
783.8	8.65	3.00	2.8 :	108.9	7.32	2.61	2.10				
799.0	8.86	3.12	...	112.0	7.36	2.61	1.97				
807.8	9.07	3.17	2.8 :	113.9	7.40	2.65	2.02				
814.8	9.23	3.26	3.5 :	118.9	7.45	2.65	2.09				
821.8	9.31	3.27	3.3 :	120.8	7.45	2.73	2.03				
838.9	9.55	3.27	...	123.8	7.51	2.69	2.07				
897.1	9.53	3.24	...	126.8	7.55	2.69	2.04				
918.1	8.69	2.98	3.4 :	129.8	7.56	2.75	2.17				
951.1	7.81	2.67	3.4 :	132.8	7.63	2.75	2.17				
964.0	7.64	2.68:	3.9 :	139.8	7.74	2.73	2.28				
967.0	7.78	2.65	3.1 :	145.8	7.84	2.76	2.35				
988.0	7.75	2.62	3.4 :	147.9	7.86	2.80	2.39				
991.0	7.77	2.67	3.0 :	150.8	7.91	2.77	2.49				

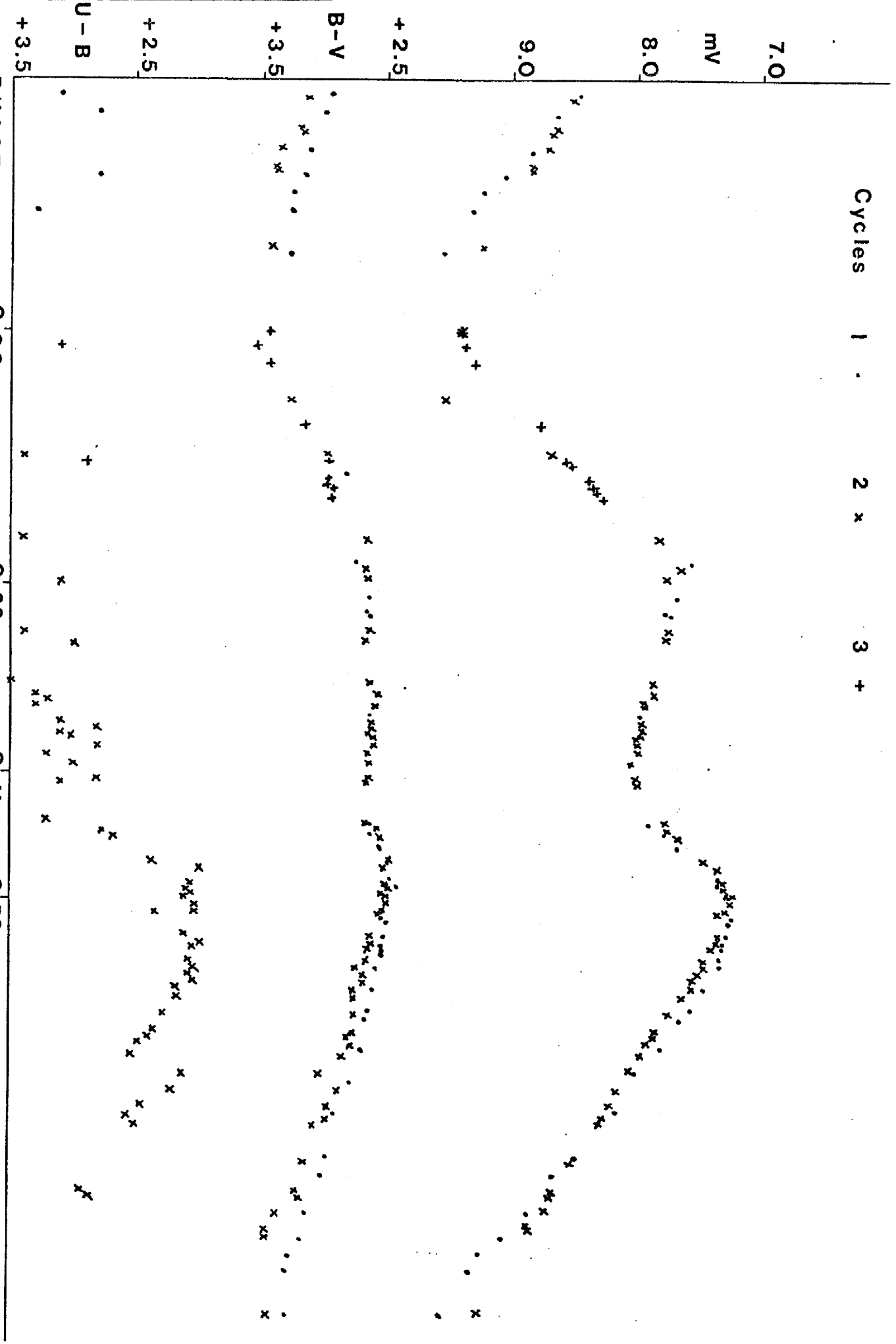

FIGURE 1 WELCH'S RED VARIABLE STAR IN CRUX UBV OBSERVATIONS

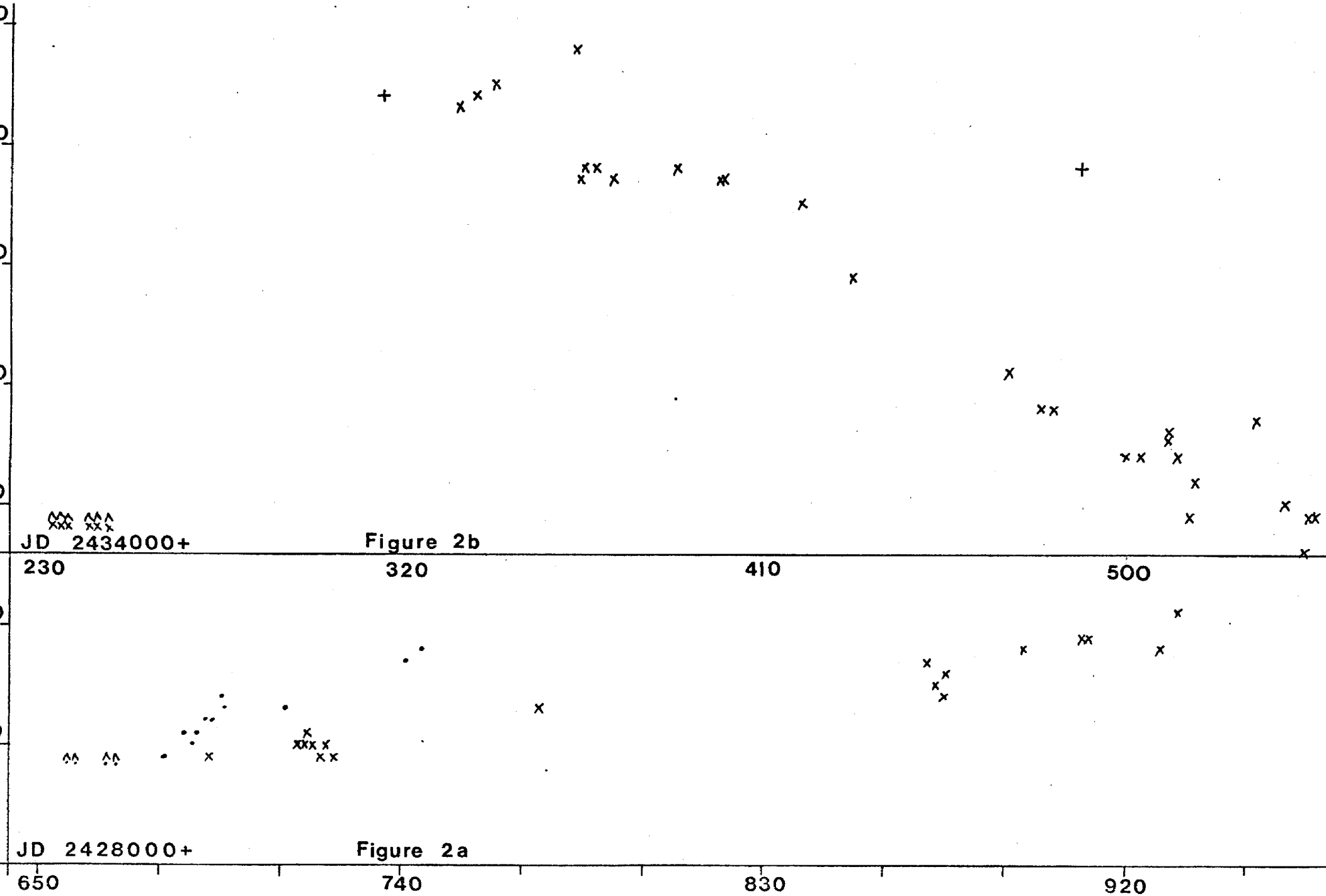

FIGURE 2 SONNEBORG OBSERVATIONS ORTHO · PAN + BLUE SENSITIVE ×

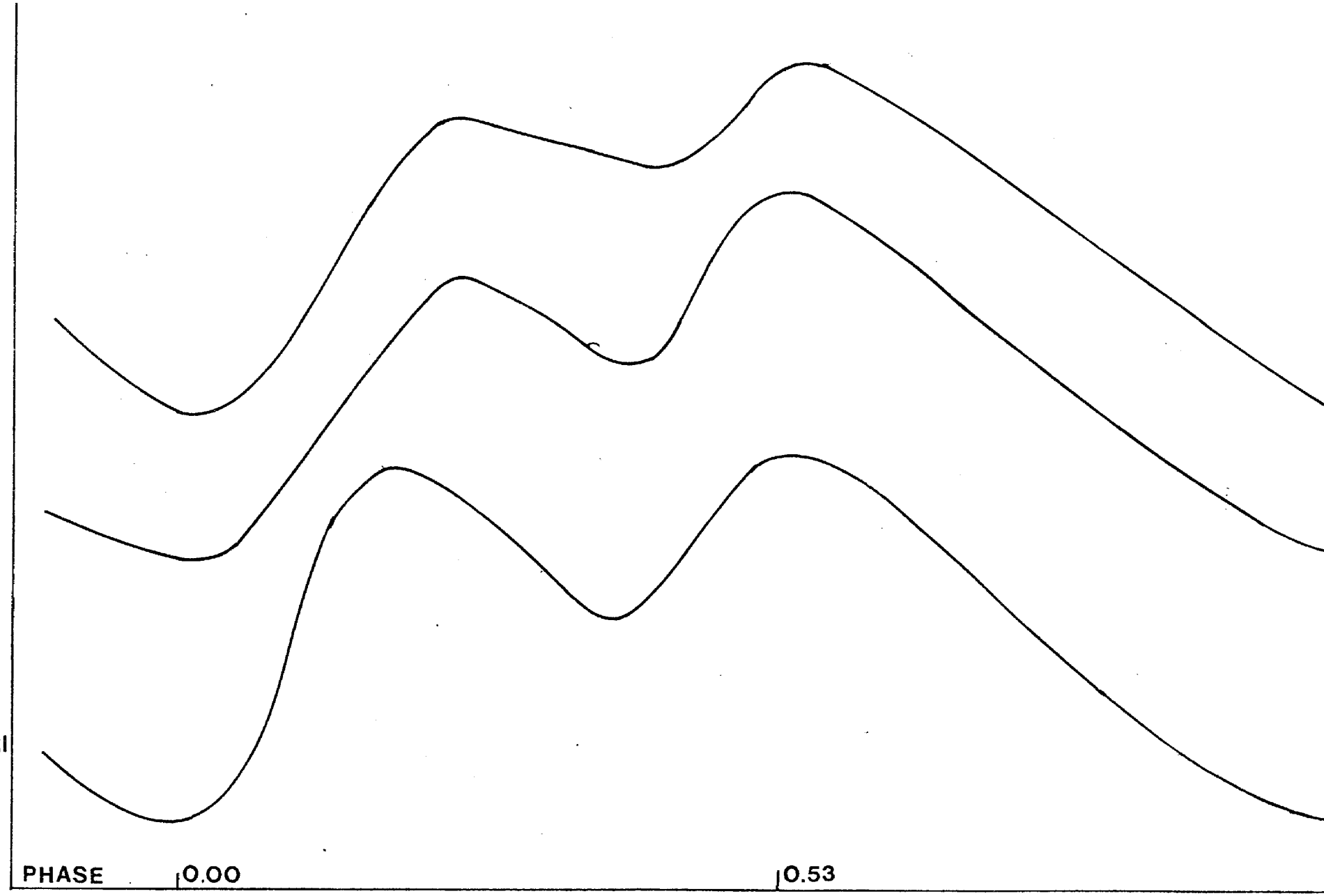

FIGURE 3 WELCH'S CRUCIS VARIABLE, R NORMAE AND R CENTAURI – AMPLITUDE AND PERIOD REDUCED TO COMPARABLE SCALE