PHOTOELECTRIC OBSERVATIONS OF DS ANDROMEDAE AND RZ PYXIDIS

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New photoelectric measurements for the two eclipsing binaries DS Andromedae and RZ Pyxidis are presented and discussed.

I. DS Andromedae

The eclipsing variable DS Andromedae (= BD +37°435, Trumpler No. 45,F3) is situated within one cluster radius from the center of the galactic cluster NGC 752. Its variability was first reported by Alksnis (1958, 1961) who had measured 60 photographic plates. He derived a period of 1.010508 days. The light curve showed two minima of unequal depth. In the same year, Strohmeier and Ott (1961) applied Alksnis' period to their photographic data of DS And and concluded that Alksnis' period of primary minimum had to be shifted by 0.094 days to represent their data. Their shift, however, no longer represented Alksnis' minima.

During 1967, DS And was observed photoelectrically on three nights with the 24-inch reflecting telescope at the Lick Observatory during the writer's search for δ Scuti stars in the cluster. DS And was observed when the search for δ Scuti stars was no longer possible. The differences in magnitude, ΔV, between the variable and comparison star (Table I), however, still have a standard error of less than $0^m.01$. It must be pointed out that the purpose was not to obtain a full orbital and physical solution for the system. This would be difficult because the period is so close to one day. The determination of mass and luminosity, however, is important since DS And is a probable member of NGC 752. Miss Roman (1955) rejected DS And as a member of NGC 752 on the basis of its radial velocity (a mean of +55 km/sec from two plates compared to the cluster mean of −4 km/sec). However, Ebbighausen (1939) concluded that DS And is a probable member of the cluster (his class 2) on the basis of its proper motion.

TABLE I

PHOTOELECTRIC OBSERVATIONS OF DS AND

$JD_{\odot}2430000.+$	Phase	ΔV	$JD_{\odot}2430000.+$	Phase	ΔV
9748.9424	.998	$+^{m}854$	9754.028	.031	$+^{m}771$
.9458	.002	.845	.7455	.741	.384
.9660	.022	.832	.7518	.747	.397
.9722	.028	.798	.7587	.754	.419
.9778	.033	.766	.7726	.768	.367
.9806	.036	.736	.7775	.773	.399
.9868	.042	.695	.7830	.778	.403
9749.0014	.057	.589	.7969	- .792	.379
.0069	.062	.570	.8080	.803	.373
.0097	.065	.547	.8261	.821	.397
.0125	.068	.533	.8372	.832	.405
.0181	.073	.509	.8483	.843	.416
.0208	.076	.497	.8587	.853	.408
.0236	.079	.479	.8761	.870	.430
.0264	.081	.473	.8872	.881	.442
.0292	.084	.471	.8934	.887	.421
.0319	.087	.467	.9094	.903	.446
.0347	.090	.458	.9170	.911	.490
.0424	.097	.459	.9309	.924	.509
9753.856	.862	.375	.9532	.947	.642
.913	.917	.490	.9657	.959	.748
.940	.944	.606	9755.0136	.006	.879
.963	.967	.804	.0247	.017	.849
.977	.980	.867	.0316	.024	.822
.997	.000	.892	.0379	.030	+.811
9754.014	.017	+.848			

The nearby cluster member BD +37°434 (F5) was used as a comparison star. A test made with the No. 2 36-inch telescope at the Kitt Peak National Observatory showed the comparison star to be constant to $\pm 0^{m}002$ (standard error per *single* measurement) as compared to two other nonvariable F stars.

Strohmeier and Ott's revision of Alksnis' epoch of primary minimum does not predict the times of the new minima. We found that Alksnis' original epoch with a slightly increased period can fit *all* the observed minima. This does not increase the reported

observed minus computed ($O-C$) values given by Strohmeier and Ott. We now find a mean phase shift $\Delta\phi = +0.004 \pm 0.012$ for *their* dates of minimum, as compared to the original $\Delta\phi = +0.013 \pm 0.009$. The new elements for primary minimum are:

$$\begin{array}{l} \mathrm{JD}_{\odot}2436142.401 + 1^{d}01519E \\ \pm 0\ .00001 \end{array} \quad . \qquad (1)$$

The photoelectric light curve is shown in Figure 1, where ΔV represents V (DS And) $-V$ (BD $+37°434$).

Although only limited data are available for DS And, a few conclusions can still be drawn.

(1) The photographic light curve shows that the two minima are equally spaced in phase indicating that the system has zero, or very small, orbital eccentricity.

(2) Within present photoelectric accuracy, the primary eclipse is symmetrical about the minimum. The scatter near maximum is much larger than can be expected from photoelectric photometry alone. We believe the scatter to be intrinsic. This has also been noted in many other short-period eclipsing systems (Schmidt and Schrick 1955, 1956).

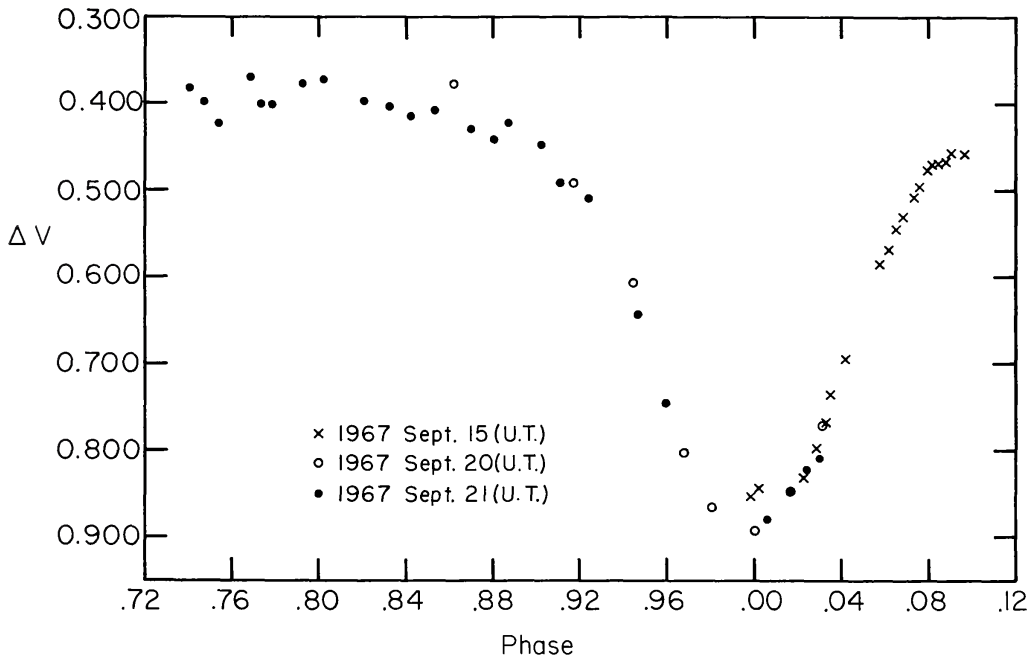

FIG. 1 — The primary eclipse of DS And in NGC 752. The phases have been derived assuming a revised period of 1.010519 days.

(3) Let $1-l_1$, $1-l_2$ be the amounts of light removed during the two eclipses and let L_1 and L_2 be the luminosities of the two stars with radii r_1 and r_2 respectively. Then, neglecting limb darkening effects, we find that

$$\frac{1-l_1}{1-l_2} = \frac{L_1 r_2^2}{L_2 r_1^2} \qquad (2)$$

The depth of primary minimum is approximately twice the depth of the secondary eclipse (in photographic light). After a preliminary rectification of the light curve the value of equation (2) becomes 0.8. Since Miss Roman (1955) classified the system as a F3 *dwarf,* the stars have to be fairly close in spectral type. The equation can be fitted by an F3 and an F5 dwarf, using values of L and r given by Allen (1963). This makes the secondary star less than a magnitude fainter than the primary. Presumably Roman did not detect any line doubling. Considering that she used spectrograms of low dispersion 113 Å/mm, had only two spectra showing similar velocities, and that the secondary could be up to a magnitude fainter, it is quite possible that her observations were nearly at the same phase; hence the expected line-doubling was simply not detected.

II. RZ Pyxidis

RZ Pyxidis (HD 75920, B7 V) was discovered by Hoffmeister (1936) to be a short-period variable. Kaho (1937) deduced that RZ Pyx was a RR Lyrae star of Bailey type c. Kinman (1960), however, observed RZ Pyz fully and found that it was an eclipsing binary with a period close to two-thirds of a day.

At the request of the Astronomer Royal this star was reobserved in 1963-64 with the 24-inch refractor at the Royal Observatory (Cape). The comparison star used was HR 3490 = HD 75112. Its magnitude and color were assumed to be as given by Cousins and Stoy (1963). The B and V magnitudes are on the Johnson UBV system, while the $(U-B)_c$ magnitudes have been described by Cousins and Stoy (1963). The observational data are tabulated against the phases derived from equation (3) in Table II and the light curve, together with Kinman's measurements, is shown in Figure 2. The new observations suggest a slightly steeper minimum and a wider maximum, but the change is small and might be caused

TABLE II

PHOTOELECTRIC OBSERVATIONS OF RZ PYX

$JD_{\odot}2438000.+$	Phase	B	$(B-V)$	$(U-B)_c$
387.552	.825	$9^m.14$	$-0^m.09$	$1^m.32$
.565	.845	9 .05	−0 .10	1 .32
411.513	.335	9 .11	−0 .07	1 .30
.517	.342	9 .07	−0 .09	1 .31
416.506	.943	8 .84	−0 .07	1 .31
.521	.969	8 .86	−0 .08	1 .32
.552	.006	8 .88	−0 .07	1 .30
421.366	.350	9 .04	−0 .09	1 .31
.371	.358	9 .01	−0 .09	1 .27
.382	.373	8 .94	(−0 .06)	(1 .31)
.385	.379	8 .94	−0 .08	1 .30
.419	.431	8 .87	−0 .09	1 .29
427.351	.470	8 .85	−0 .09	1 .30
.362	.486	8 .83	−0 .09	1 .30
.364	.490	8 .84	−0 .07	1 .29
.368	.495	8 .83	−0 .08	1 .29
.389	.528	8 .84	−0 .08	1 .30
.392	.532	8 .85	−0 .08	1 .30
.396	.538	8 .85	−0 .08	1 .30
427.405	.551	8 .86	−0 .08	1 .30
.408	.557	8 .86	−0 .09	1 .34
.412	.562	8 .86	−0 .09	1 .30
.421	.577	8 .88	−0 .08	1 .32
.425	.582	8 .88	−0 .09	1 .32
.428	.587	8 .88	−0 .09	1 .30
.438	.602	8 .91	−0 .08	1 .31
.444	.612	8 .93	−0 .09	1 .29
.455	.629	8 .95	−0 .08	1 .31
.459	.634	8 .96	−0 .08	
.489	.680	9 .16	−0 .07	1 .28
.493	.686	9 .19	−0 .08	1 .30
.498	.693	9 .25	−0 .10	1 .32
.508	.707	9 .37	−0 .06	1 .30
.512	.714	9 .41	−0 .06	1 .29

TABLE II (Continued)

$JD_{\odot}2438000.+$	Phase	B	$(B-V)$	$(U-B)_c$
.514	.718	9^m47	-0^m07	1^m30
.526	.736	9 .62	−0 .08	1 .31
.530	.743	9 .66	−0 .06	1 .31
.534	.748	9 .68	−0 .08	1 .32
.544	.763	9 .60	−0 .08	1 .31
.547	.768	9 .57	−0 .07	1 .30
431.424	.676	9^m19	-0^m07	1^m29
.427	.680	9 .21	−0 .08	1 .30
.437	.696	9 .31	−0 .09	1 .30
.440	.700	9 .33	−0 .09	1 .33
.444	.706	9 .36	−0 .10	1 .30
431.447	.711	9 .42	−0 .09	1 .30
.457	.726	9 .56	−0 .09	1 .31
.460	.731	9 .60	−0 .09	1 .33
.479	.760	9 .67	−0 .11	1 .30
.482	.764	9 .65	−0 .11	1 .30
.492	.779	9 .52	−0 .08	1 .29
.494	.783	9 .47	−0 .11	1 .28
.500	.791	9 .40	−0 .10	1 .29
.503	.796	9 .36	−0 .12	1 .30
.514	.813	9 .24	−0 .11	1 .30
.518	.819	9 .20	−0 .10	1 .31
455.440	.271	9 .55		
.442	.273	9 .53		
.443	.274	9 .52		
.444	.276	9 .51		
.445	.277	9 .48		
.446	.279	9 .48		
.447	.280	9 .45		
464.336	.825	9 .16	−0 .12	1 .33
.343	.837	9 .07	−0 .12	1 .33
.400	.923	8 .88	−0 .09	1 .26
.408	.936	8 .86	−0 .10	1 .24
468.323	.900	8 .92	−0 .08	1 .31
.455	.102	8 .93	−0 .08	1 .32

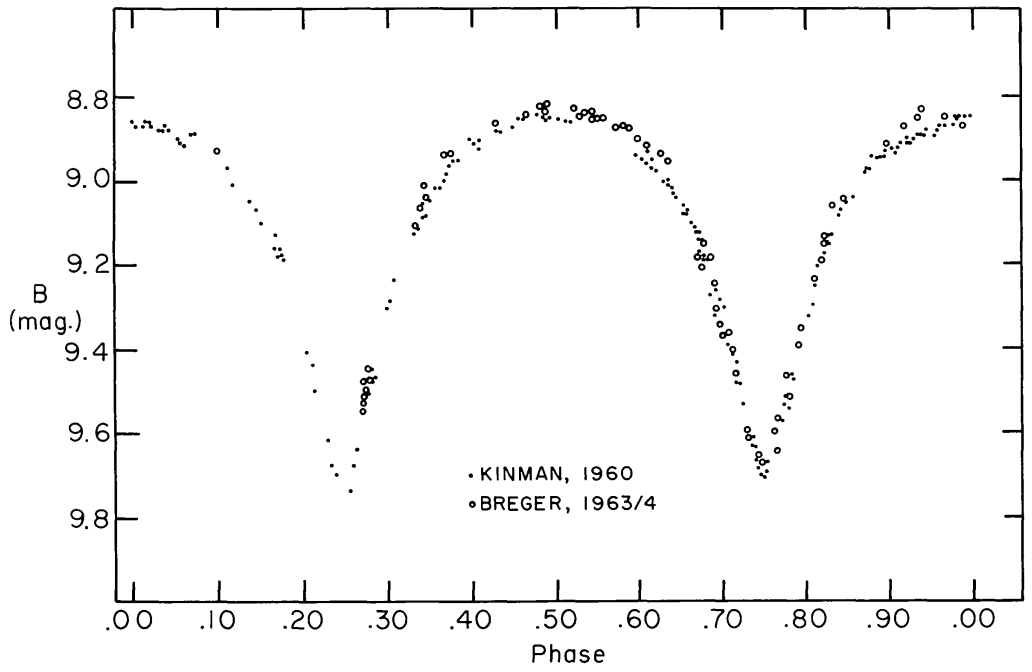

FIG. 2 — Light curve of the close-eclipsing binary RZ Pyx.

by small systematic magnitude differences. We find no detectable color changes during the cycle. The following elements for minimum light are derived from both Kinman's and our minima:

$$JD_{\odot} = 2438431.474 + 0.656273E \pm 0.000001 \quad . \qquad (3)$$

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REFERENCES

Allen, C. W. 1963, *Astrophysical Quantities* (London: Athlone Press).
Alksnis, A. 1958, *Astr. Tsirk.* **194**, 25.
—— 1961, *Var. Star Bull.* **13**, 300.
Cousins, A. W. J. and Stoy, R. H. 1963, *Royal Obs. Bull.* **64**.
Ebbighausen, E. 1939, *Ap. J.* **89**, 431.
Hoffmeister, C. 1936, *A.N.* **258**, 39.
Kaho, S. 1937, *Tokyo Astr. Bull.* **209**.
Kinman, T. D. 1960, *Mon. Notes R.A.S. South Africa* **19**, 62.
Roman, N. G. 1955, *Ap. J.* **121**, 454.
Schmidt, H. and Schrick, K. W. 1955, *Zs. f. Ap.* **37**, 73.
—— 1956, *Zs. f. Ap.* **41**, 1.
Strohmeier, W. and Ott, H. 1961, *Veröff. Remeis-Sternw. Bamberg* **5**, **12**, 2.