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THE PERIOD OF AZ CASSIOPEIAE

AZ Cassiopeiae is a long-period (9.3 years) spectroscopic-eclipsing binary, a member of the VV Cephei group. Although discovered much earlier, its type of variability was first recognized by Ashbrook in 1956, who derived the following ephemeris formula based on the Harvard plate collection: Min.=J.D. 2432484 + 3406 E, D = 112d, d = 92d. The system was neglected for some time but its latest eclipse in 1975 attracted wider attention. In the following we will present the results of measurements relevant to the 1956-57 eclipse derived from plates in the University of Oklahoma, Norman, archive. In the light of these measurements and other results, both published and unpublished, we will also discuss the period of the variable which repeatedly exhibited noticeable deviations from the predicted contact times.

1. The AZ Cas plates in the Norman collection were taken by Professor B. S. Whitney, using the 85 mm Zeiss camera and Kodak 103a0 material. They run from May 1956 to March 1957 and bracket the ingress phase, without actually covering the first or second contact. The iris-photometer measurements were based on a B-sequence selected from the Naval Observatory Photoelectric Catalogue. (Blanco *et al.*, 1968) Observations closest to the 1956 ingress phase are listed below.

	Maximum, m_b		Minimum, m_b	
J.D. (2435)	696.867	10.80	... 833.666	11.73
	696.876	10.90	833.677	11.93
	725.730	10.96	834.729	11.71
	725.796	10.97	834.741	11.82
	773.681	10.81	834.760	11.74
	773.698	11.01	838.737	11.57
	802.645	10.97	838.755	11.42
	802.658	10.93	859.616	11.64

The mean magnitude at maximum is 10.92, std. deviation ±0.09, and the mean magnitude at minimum is 11.72, std. deviation ±0.15, giving an amplitude close to the B amplitude found photoelectrically by Larson-Leander. The higher error of the minimum measurements probably indicated an increase in the level of brightness fluctuations. It can also be noted that some features of these brightness fluctuations during minimum may return with a possible regularity in that a drop in brightness immediately following second contact or immediately preceding third contact is noted in the Norman observations as well as in observations of the 1947 and 1966 eclipses.

2. The following discussion of the period is based, to a great extent, on unpublished material generously provided by Dr. J. Ashbrook (details of 5 minima from Harvard patrol plates) and by Professor P. Tempesti (photoelectric observations at Teramo, timing of ingress 1975). Further basic information concerning past minima can be found in reports by Richter (1957, 1966), Larsson-Leander (1959) and Tempesti (1968); observations by Weber at Mainterne were not available to us.

Instead of estimating the contact times, we considered the mid-points of the ingress and egress partial phases ("mid-ingress" and "mid-egress") and constructed separate O-C curves for them. The mid-points are defined as being equidistant in magnitudes from the maximum and minimum brightness. This procedure has already been applied to Zeta Aur (Herczeg, 1956, Hardorp *et al.*, 1966) and seems particularly well suited in the case of AZ Cas, where among the 8 eclipses observed since 1901, only one (1947) gave reliable information on both egress and ingress. We are well aware of a possible pitfall: the run of the eclipses (partial phases) is somewhat different in different colors. The significant discrepancy lies, however, between U and B, not between B and V; this is clearly indicated by the behavior of the similar systems, Zeta Aur, 31 and 32 Cyg. For AZ Cas, most of the photographic and B observations suggest a duration of the partial phase around 10 d, while the photoelectric V observations of the last three eclipses show a somewhat shorter, 8d duration. Thus, the error in our determination of the mid-partial phases is about 1 day at most and in all likelihood considerably less.

We also made a limited use of those series, both photographic and photoelectric, which failed to indicate the mid-eclipse point. In these cases, observations taken clearly at maximum or minimum usually define a possible interval for the mid-point, bracketing it. Using the previously discussed limits on the duration of the partial phase, such a bracket can be improved by taking t_1+4 and t_2-4 instead of t_1 and t_2. It is clear that the "mid-points" do not necessarily fall halfway between the epochs of the corresponding contacts. The photoelectric observations actually show them shifted by about 1 day toward the 2nd and 3rd contact. This shift is hardly noticeable photographically but a small systematic error in the table below and in the figure can arise as a result.

We derived epochs or brackets for the mid-epochs from all observations. Ascribing E = 0 to the well covered 1947 eclipse, the following tables of residuals were constructed, using Ashbrook's period, P = 3406 days.

Mid-ingress:

E = -5	O = (24)15405 ± 5	O-C = -3 to +7	Harvard (1 obs.)
-2	25603 to 622	-18 to +1	Harvard
-1	>29019	>-9	Sonneberg (1 obs.)

E = 0	32433±2	0(def.)	Harvard
+1	35806 to 829	-33 to -10	Norman
+2	39225 to 230	-20 to -15	Sonneberg; Teramo (phe)
+3	42640±1	-11	Teramo (phe)
Mid-egress:			
E = -3	0 = (24)22298 to 318	0-C = -17 to +3	Harvard
-1	29124 to 127	-3 to 0	Harvard
E = 0	32533±1	0 (def.)	Harvard
+1	35933±1	-6	Lund (phe)
+2	39335±1	-10	Teramo (phe)

Comparison with the Harvard observations show that in 1947 the apparent decline on the Sonneberg plates after 2432415 was merely a fluctuation and the eclipse did not begin until J.D. 2432430. This may explain the low value of the period, 3397d, deduced earlier from Sonneberg material.

From the tables above, two pieces of useful information can be extracted:

A. Ashbrook's ephemeris represents all earlier eclipses (E=-5 through E=0) quite satisfactorily.

B. The same formula certainly fails for the more recent eclipses. These can be represented in an acceptable way by a new ephemeris formula we propose;

Min. = J.D. 2432483 + 3402 E $(E \geq 0)$; D = 110d, d = 90d .

This new formula is equivalent with the statement that in or around 1947 the period abruptly changed by -4 days (see fig.). As 32 Cyg may have exhibited similar behavior (Doherty 1967, Wright 1970) and considering the strongly interacting nature of the AZ Cas system, this is by no means an implausible proposal.

It can be noted that the erratic behavior of the system makes exact prediction of the eclipses difficult. For example, mid-ingress for 1956 is predicted by our formula to have occurred on J.D. 2435835. Norman observations show beyond doubt that the B-component was already completely eclipsed on J.D. 2435833, indicating that mid-ingress occurred at least 6 days earlier. The occurrence of a significantly early ingress in 1966 is also well documented.

For the 1975 eclipse our formula gives: mid-egress JD. 2442739, that is, third contact: Nov. 17±1, forth contact: Nov. 27±1.

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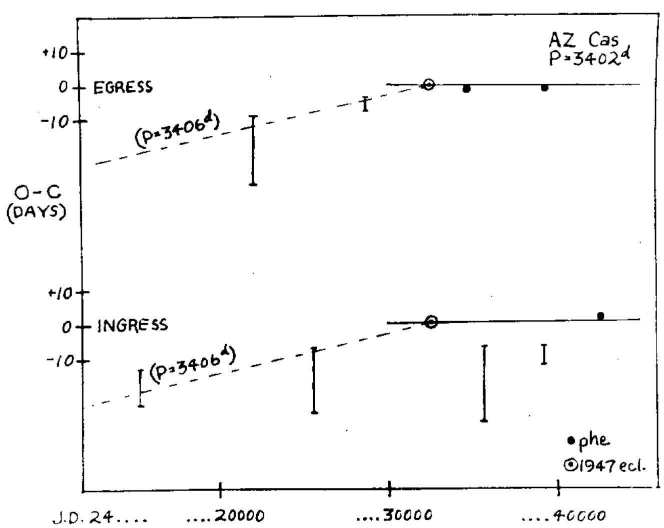

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