A POSSIBLE SECONDARY MINIMUM OF THE LONG-PERIOD ECLIPSING BINARY OW GEM (NSV 3005)

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Abstract

Photoelectric photometry of the 1258-day eclipsing binary OW Gem = NSV 3005 during the 1988-89 season found the star constant at maximum except for the interval JD 2447531-540, when it was almost 0.1 magnitude fainter. If the observed event was the secondary eclipse, the unseen companion is a large cool star, probably a late-G to early-M giant, and the orbit of the binary system is highly eccentric with secondary minimum occurring at phase 0.23 of the photometric period.

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Kaiser et al. (1988) reported observations of a deep eclipse (1.8 magnitude **V**) of NSV 3005 (BD +17 1281, HD 258878, SAO 95781), and Kaiser (1988) determined a period of 1258.56 days from Harvard patrol plates. Subsequently, the variable received the official designation OW Geminorum (Kholopov et al. 1989). The system is of interest because the F2II primary is luminous enough to possess a cooler giant companion, a likely inference from the depth of primary eclipse and its duration, 12-14 days.

Percy (1988) noted that the primary is also close to the Cepheid instability strip and might be a small-amplitude pulsating variable. To test this suggestion, I have continued to observe OW Gem in the **V** passband with a 28-cm Schmidt-Cassegrain telescope and Optec SSP-3 photometer. Comparison and check stars used are shown in Table I. The comparison star's magnitude and color index are from my observations reported in Kaiser et al. (1988). The check star magnitudes were determined differentially from the comparison star using the given **B-V** values from **Sky Catalogue 2000.0** (Hirshfeld and Sinnott 1982) for transformation to the **V** system.

My observations of OW Gem are listed in Table II. Each mean differential magnitude has been corrected for extinction and transformed to the **V** system. Five previously published observations (Kaiser et al. 1988), which were originally expressed in magnitudes and rounded to 0.01 magnitude, are included in Table II in differential form to three decimal places.

Observations indicate that the comparison star was constant. But winter sky conditions were often less than ideal. The standard deviation of the mean differential magnitudes of the variable and check stars is $\pm$0.02 magnitude, so variability of one or more stars with a total range of 0.05 magnitude or less cannot be ruled out. However, the residuals of the variable and check stars in each night's data do not correlate and most probably represent observational scatter.

OW Gem was normally constant at 8.24 **V** (Figure 1). But on three nights between JD 2447531-540, the variable was fainter than normal by 0.08-0.11 **V**, a decrease certainly larger than the observational errors. The observed change does not resemble any familiar form of intrinsic variability. The interpretation that comes most readily to mind is a secondary eclipse of the binary system. The duration of primary eclipse was estimated at 12 - 14 days (Kaiser et al. 1988), so the duration of this presumed secondary eclipse, more than 9 days and less than 20 days, is within the same order of magnitude.

Other explanations for the observed variation are difficult to credit. The constant light of the binary system except during this singular event would seem to eliminate common types of intrinsic variability, which are repetitious even when not strictly periodic. The gaps in the light curve due to weather may conceal additional variations, but it would be highly fortuitous for all 23 observations outside the minimum to fall within ± 0.02 magnitude of a constant value. An eclipse by a third component in the system is possible, but I am not aware of any multiple star with eclipses involving more than two components.

The possibility of error in making or reducing the observations must also be considered. Observations were made on 12 nights prior to the first fainter observation, so the field was very familiar. No other star in the field except the comparison star is within 0.5 magnitude of the variable at maximum, so measurement of the wrong star could not produce the observed differential magnitudes. The change in relative brightness between the variable and the comparison star is apparent in the raw photometer counts, so the minimum is not an artifact of errors in the data reduction process.

If the observed variation is the secondary eclipse, the ratio of the primary and secondary minima depths indicates that the unseen component is two to three spectral classes cooler than the primary, a late-G to early-M star. The depth of primary eclipse, 1.8 magnitude, shows that the companion is occulting more than 80 percent of the F2II primary's luminous surface and therefore is also a giant star. The orbits must also be highly eccentric, with secondary eclipse occurring at phase 0.23 of the photometric period.

The observed minimum would be close to phase 0.5 if the period were actually half the value determined by Kaiser (1988), but he found plates showing the variable at maximum at all the simple submultiples from 1/2 to 1/20 of the 1258-day period. High eccentricity in long-period eclipsing binaries is not unusual, for example HR 6902 (385 days, e = 0.31), tau Persei (1515 days, e = 0.74), and AZ Cas (3404 days, e = 0.55).

Observations will be continued next season. A lack of further variations will support the premise that the observed minimum was the secondary eclipse. Final confirmation by photometry will require the observation of an identical minimum after one orbital revolution. Unfortunately, with a 3.45-year orbital period, the next predicted epoch occurs near solar conjunction, and it will be seven years before the same phases of the light curve can be observed again.

Spectroscopic observations could provide a quicker answer by determining the orbital eccentricity from the radial velocity variations, confirming or denying the possibility that the observed minimum could be the secondary eclipse.

REFERENCES

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TABLE I

Comparison and Check Stars for OW Gem

	Star	V	B-V	Spectrum
Comparison	HD 46198, SAO 95810	7.92	+0.50	A0
Check 1	HD 46264, SAO 95819	7.64	-0.02	B5
Check 2	HD 46017, SAO 95773	7.01	+1.1	K2

TABLE II

Differential **V** Magnitudes, OW Gem - HD 46198 (SAO 95810)

HJD	(n)	ΔV	σ_1	HJD	(n)	ΔV	σ_1
2447255.570	(5)	+0.297	±0.009	2447548.638	(4)	+0.279	±0.011
259.602	(3)	0.320	0.020	.682	(4)	0.339	0.019
260.593	(3)	0.303	0.021	.722	(4)	0.314	0.011
264.571	(3)	0.335	0.014	549.638	(4)	0.316	0.012
265.566	(3)	0.335	0.018	.681	(4)	0.315	0.009
271.579	(3)	0.287	0.015	.722	(4)	0.307	0.011
498.794	(3)	0.286	0.021	553.646	(5)	0.309	0.018
.820	(3)	0.321	0.030	.683	(3)	0.324	0.009
502.706	(3)	0.306	0.011	554.682	(5)	0.332	0.030
507.710	(4)	0.305	0.004	.726	(4)	0.332	0.022
526.733	(4)	0.331	0.008	581.571	(6)	0.321	0.028
531.710	(5)	0.399	0.005	608.592	(4)	0.296	0.014
537.712	(5)	0.417	0.018	609.552	(4)	0.302	0.016
540.739	(5)	0.389	0.027				

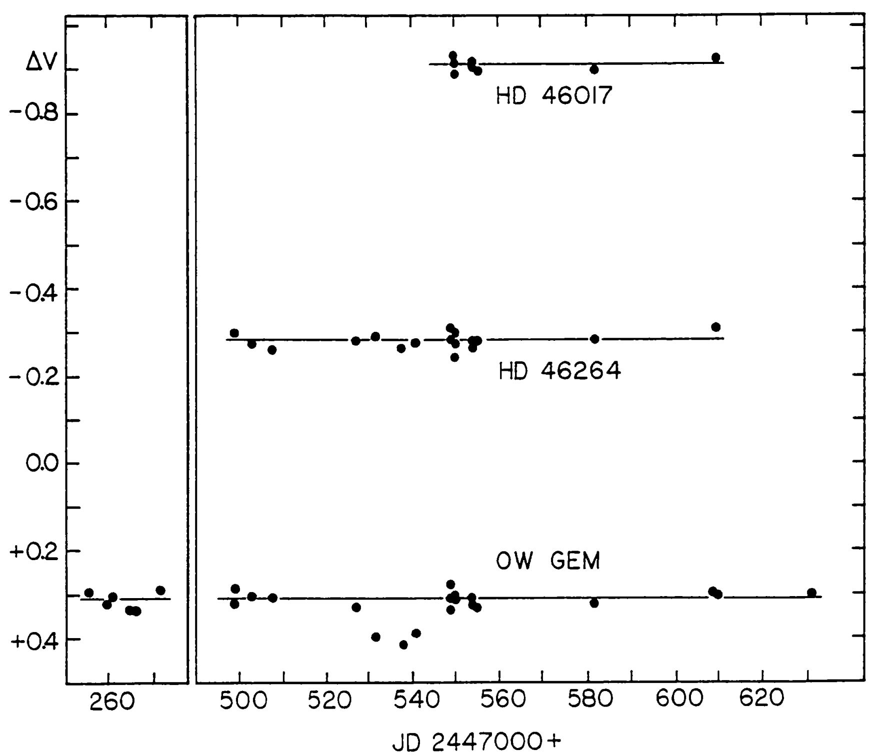

Figure 1. Photoelectric differential **V** observations of check stars and the long-period eclipsing binary OW Gem relative to the comparison star HD 46198.