A NEW PERIOD AND PERIOD CHANGES OF GG CASSIOPEIAE

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Abstract. The O–C diagram of the eclipsing binary GG Cassiopeiae has been presented for the first time, and the period changes present in the system have been analysed. In all three period changes are noted. The strongest period change has been found to occur in the time-interval 1942 to 1966. The total period change in different portions of the O–C diagram ranges from 7.1×10^{-7} d to 2.0×10^{-5} d. The stronger period changes appear to have occurred after 1942; prior to it, the system has shown a negligible period change. The overall picture of the O–C diagram suggests that the O–C values of the system GG Cas are negative after 1942. The presence of a third body does not appear probable. The period fluctuations are also appreciable. A new period ($P = 3\overset{d}{.}758733$) has been presented.

1. Introduction

The eclipsing binary system GG Cassiopeiae (BD + 55°274) was discovered to be a variable by Leiner (1922, 1944), who declared it to be an Algol-type variable (Leiner, 1944). Herbig (1952), Popper (1956), and Azimov (1963) presented spectral types of the system. Orbital elements of the system have been derived by Srivastava and Kandpal (1970) and Chaubey (1984). Shulov (1967) and Pfeiffer and Koch (1977) searched for polarization in GG Cas. No detailed period study of the system is available in the literature.

2. Epoch, Period, and New Period

Leiner (1944), Azimov (1963), Srivastava and Kandpal (1970), and Lichtenknecker (1980) presented the epochs of minima and/or the period of the system. These are listed in Table I. Unfortunately, the secondary minima of GG Cas are not available. The epoch found from the earlier observations (E.O.) gives a different period than the other. The period was improved by Leiner (1944). It is evident from Table I that the period suddenly changed around 1942, and another slight change in period appeared to have occurred till the last epoch. The trend of this period change appears incomplete. The first epoch of Table I, quoted by Leiner (1944) appears inaccurate as it gives unusual O–C value (Table II), which is completely different from others.

We have collected all (11) available primary minima of GG Cas from the literature. Out of these, only two minima (of Srivastava and Kandpal, 1970) are photoelectric and the remaining are photographic and visual. We have also determined the epochs of first three minima in the light of Leiner's (1944) quotations. The last minima is, of course, visual. From all these minima, leaving the fourth one, we have obtained a new period of GG Cas after several trials using the method of least-squares. The new period comes

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TABLE I

Epoch and period of GG Cassiopeiae

S. No.	Author	Epoch and period
1	E.O. (cf. Leiner, 1944)	J.D. 2430127.600(?) + $3\overset{d}{.}7591$
2	Leiner (1944)	J.D. 2430188.468 + $3\overset{d}{.}758738$
3	Azimov (1963)	– + $3\overset{d}{.}75874$
4	Srivastava and Kandpal (1970)	J.D. 2430188.468 + $3\overset{d}{.}758719$ (± $0\overset{d}{.}000005$)
5	Srivastava (present work)	J.D. 2425238.210 + $3\overset{d}{.}758733$ ± $0\overset{d}{.}000001$)

TABLE II

Primary minima of GG Cassopeiae

J.D.$_{\odot}$	Cycles	Mean of cycles	O–C	Mean of O–C	Weighted mean of O–C	Reference
2425238.210	0		$0\overset{d}{.}000$		$0\overset{d}{.}000$	E.O. (cf. Leiner, 1944)
2429907.265	178	715	0.000	0.000	0.000	E.O. (cf. Leiner, 1944)
2429940.391	1251		0.000			E.O. (cf. Leiner, 1944)
2430127.600	1301		− 0.726		− 0.726(?)	E.O. (cf. Leiner, 1944)
2430188.468	1317		+ 0.002			Leiner (1944)
2430188.468	1317	1410	+ 0.002	+ 0.001	+ 0.001	Leiner (1944)
2430466.622	1391		+ 0.007			Leiner (1944)
2430643.270	1438		− 0.005			Leiner (1944)
2430857.523	1495		0.000			Leiner (1944)
2438713.2338	3585	3784	− 0.0512	− 0.047	− 0.047	Srivastava and Kandpal (1970)
2440209.2202	3982		− 0.0428			Srivastava and Kandpal (1970)
2444490.429	5122		− 0.037		− 0.037	Lichtenknecker (1980)

E.O. = earlier observations.

out to be $3\overset{d}{.}758733$ (± $0\overset{d}{.}000001$), which indicates a declining trend of the period of the system since 1942 or most probably since its first epoch, since most of the O–C values are negative.

3. O–C Diagram and Period Variations

All available primary minima of GG Cas, which have been observed between 1927 and 1980, have been collected; and O–C diagrams have been constructed from the O–C values calculated from the ephemeris:

$$\text{Primary Minimum} = \text{J.D. } 2425238.210 + 3^{d}.758738E \quad \text{(E.O.)}.$$

(cf. Leiner, 1944). Two O–C diagrams (Figures 1 and 2) have been drawn. In Figure 1, O–C values of all individual points alongwith the mean O–C values (shown by crosses) are plotted. Mean O–C values help in reducing the scatter of the points.

In order to differentiate between different types of observations, arbitrary weights of 1, 3, and 5, respectively, have been assigned to minima one to eight, minimum eleven, and minima nine and ten in the absence of availability of their observations and/or their errors. The weighted O–C values have been plotted in Figure 2.

The points inside the circle indicate the first O–C value, while the crosses in Figures 1 and 2 indicate the means and weighted means of O–C values, respectively. Filled circles

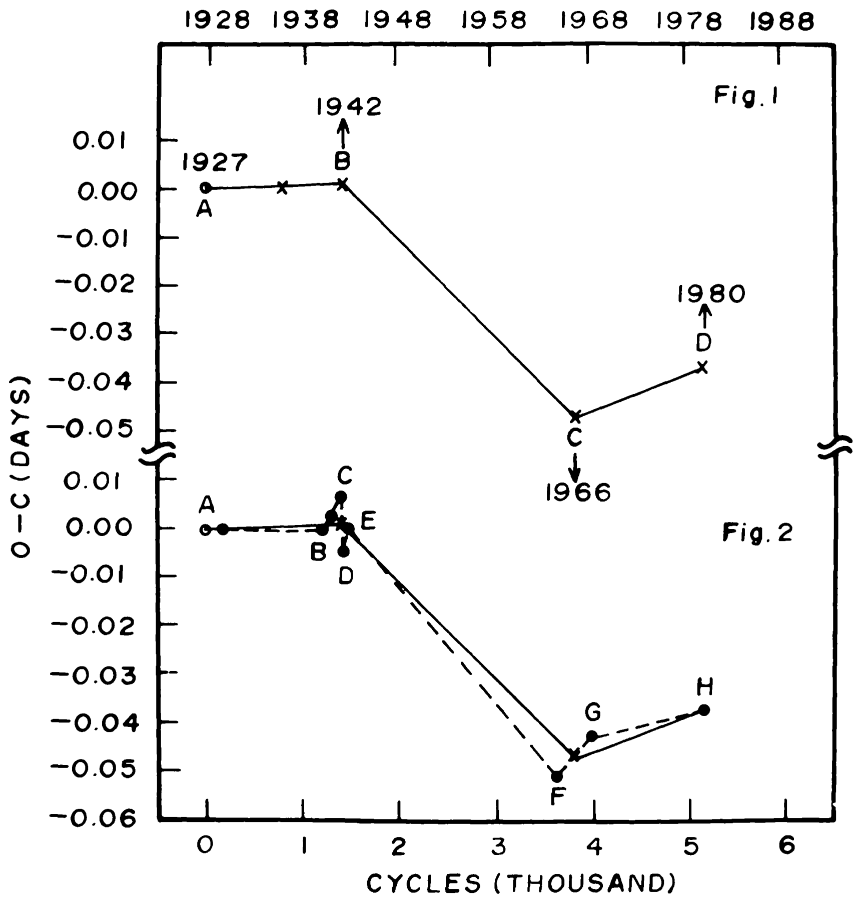

Fig. 1. O–C diagram of GG Cas based on the individual and mean O–C values. Filled circles represent the individual O–C values. Point inside a circle shows the first epoch-value, while crosses represent the mean O–C values. The solid lines represent the period changes, while the dashed lines indicate the period fluctuations.

Fig. 2. O–C diagram of GG Cas based on the weighted O–C values. The weighted O–C values are shown by crosses while the first O–C value is shown by a point inside the circle. The solid lines indicate the period changes.

are the individual O–C values in Figure 1. Dashed lines in Figure 1 represent the period fluctuations around the mean solid line.

It is apparent from Figure 1 that the period of GG Cas has remained almost constant in the interval 1927 to 1940. After this the period fluctuations have occurred in the interval 1940 to 1943. It is evident from Figure 2 that around 1942, the period of GG Cas has suddenly changed. Then the period showed again tendency to another change. Appreciable period fluctuations of the order of 10^{-5} d are apparent from Figure 1 and Table III.

TABLE III

Changes in period of GG Cassiopeiae

Portion	Interval of cycles	Total change in period (days)
	From Figure 2 (period changes)	
AB	$E = 0$ to $E = 1410$	7.09×10^{-7}
BC	$E = 1410$ to $E = 3784$	2.02×10^{-5}
CD	$E = 3784$ to $E = 5122$	7.47×10^{-6}
	Mean	9.49×10^{-6}
	From Figure 1 (period fluctuations)	
AB	$E = 0$ to $E = 1251$	0
BC	$E = 1251$ to $E = 1391$	5.00×10^{-5}
CD	$E = 1391$ to $E = 1438$	2.55×10^{-5}
DE	$E = 1438$ to $E = 1495$	8.77×10^{-5}
EF	$E = 1495$ to $E = 3585$	2.38×10^{-5}
FG	$E = 3585$ to $E = 3982$	2.12×10^{-5}
GH	$E = 3982$ to $E = 5122$	5.09×10^{-6}
	Mean	3.56×10^{-5} [a]

[a] Leaving portion *AB*.

From Figure 2, it is apparent that the period of GG Cas has shown a negligible period change between 1927 and 1942. Around 1942, the period has appreciably changed. Around 1966, the period has shown an upward trend compared to the 1942 period. The portion *AB* of the O–C diagram (Figure 2) needs no comments, as there is no appreciable period change. The point *C* is beyond any doubt since the photoelectric minimum locates this point. The point *B* is also not questionable as it is based on the weighted O–C values of a sufficient number of minima (nearly 50%). Thus, we infer that the period change between 1942 and 1966 is real. Around point *C*, the period appears to have changed. Since a solitary visual minimum lies at point *D* (Figure 2) after a lapse of nearly 14 years, and, hence, its relevance is open to question. However, it is quite clear from the O–C diagram (Figure 2) that the O–C values are mostly negative since its first epoch, and the last period is smaller than the earlier ones, hence, the period appears to have reduced. The average period change is of the order of 1×10^{-5} d, while the average period fluctuation appears to be of the order of 4×10^{-5} d. Thus, the fluctuations appear stronger than the period changes as they occur in a comparatively short interval of time (Table II). Although, sufficient minima of GG Cas are not available in the literature, and there is a complete absence of the secondary minima of the system, yet it is clear that the period of GG Cas has reduced at least since 1942, as the O–C values of the last three minima are negative.

4. Possibility of a Third Body is Negated

Although it is not possible to discuss the other causes of period changes as sufficient minima are not available, yet the following things are apparent from the O–C diagram (Figure 2):

(a) Between 1927 and 1942, the O–C value has minutely changed from $0^{\mathrm{d}}.000$ to $+0^{\mathrm{d}}.001$; and

(b) Between 1942 and 1980, most of the O–C values are found to be negative.

The change of $0^{\mathrm{d}}.001$ in the interval 1927 to 1942 is not appreciable, as it is of the order of the graphical errors in the bisection method. Hence, we feel that the period between this interval has hardly changed. O–C = $0^{\mathrm{d}}.001$ can also be caused by the errors in determination of minima, and by many other reasons. Thus, there hardly exist positive O–C values. On the other hand, after 1942, practically almost all O–C values are negative and lie below the zero-line. These facts indicate that the O–C residuals do not (equally) move around the zero-line and, thus, we infer that the presence of the third body or the existence of an optical companion as suggested by Popper (1956), may not be possible from the present data. However, the O–C diagram (Figure 2) suggests that stronger period changes are possible in GG Cas, and irregular period fluctuations are also a possibility.

5. Conclusions

Our first period study of the eclipsing binary system GG Cas reveals that appreciable period changes and period fluctuations are present in the system. The possibility of a third body may not be probable. This photoelectrically neglected system is also handicapped by the absence of secondary minima.

References

Azimov, S. M.: 1963, *Pulkovo Astrophys. Obs. Bull.* **23**, No. 173, 76.
Chaubey, U. S.: 1984, *Bull. Astron. Soc. India* **12**, 237.
Herbig, G. H.: 1952, *Trans. IAU VIII,* p. 805.
Leiner, E.: 1922, *Astron. Nachr.* **215**, 273.
Leiner, E.: 1944, *Astron. Nachr.* **274**, 181.
Lichtenknecker, D.: 1980, *BAV Mitteilungen*, No. 32.
Pfeiffer, R. J. and Koch, R. H.: 1977, *Publ. Astron. Soc. Pacific* **89**, 147.
Popper, D. M.: 1956, *Publ. Astron. Soc. Pacific* **68**, 133.
Shulov, O. S.: 1967, *Trudy Leningrad Astron. Obs.* **24**, 38.
Srivastava, J. B. and Kandpal, C. D.: 1970, *Bull. Ast*[illegible] *Cze*[illegible] No. 6, 353.