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VARIATION IN THE PERIOD OF THE SYSTEM GO CYG

M. M. ELKHATEEB
Department of Astronomy, National Research Institute of Astronomy and Geophysics (NRIAG), 11421, Helwan, Cairo, Egypt.
E-mail: magdy@nriag.sci.eg
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ABSTRACT

We present a period analysis of the well known β Lyrae type eclipsing binary GO Cyg (P= $0^d.7177$). Several new times of minimum light, recorded photoelectrically, have been gathered. Analysis of all available eclipse timings of GO Cyg has confirmed a significant period increase with rate of $2.52 \times 10^{-10} day/cycle$, also new period has been estimated. New linear and quadratic ephemerides have been calculated for the system.

Key words : Stars — Eclipsing binary — Period variation

I. INTRODUCTION

Close eclipsing binaries exhibit regular variations in their orbital periods. It is well known that many variable stars show small variations in their periods, which are due to a number of reasons: evolution, mass loss and exchange in binaries, orbital motion, etc. In order to make meaningful comparisons with theoretical predictions, observations of the rate of change of the period are needed for as many stars as possible. The probable cause for these variations in many systems is light-time effect of multiple system. However, it is also important to note those systems which have more or less constant orbital period over a time scale of a few decades. The system discussed in this paper is short period and have a long history of observations, it was discovered photographically by Schneller (1928). The short period of the system gives us the possibility to study many interesting phenomena.

II. GO CYG

The short period EB-type eclipsing binary GO Cyg (HD 197728, BD 3404095) was discovered photographically by Schneller (1929) and the system was classified as short-period eclipsing binary by Kukarkin (1929) (see Oprescu et al. 1996). Szczyrbak (1932) gave its first elements, considering the system to be of Algol type; but Kukarkin's visual observations made between 1929-1931 (Kukarkin 1932) which were subsequently analyzed by Kopal (1932) showed a β Lyrae type variation. From its early photographic (Liau 1935) and visual (Pierce 1939) observations contradictory results were found for both its light curve shape and eccentricity of its orbit (for details see Ovenden 1954). The first spectroscopic elements of the system were published by Pearce (1933). Pierce (1939) noted that the observed reflection is considerable, and the spectral type of secondary component may well of type F5 or later. The complete two-color photoelectric light curves of the star were obtained by Ovenden (1954), Popper (1957), and Mannino (1963). Ovenden analyzed his light curves by Russell's method and concluded that the observed secondary spectrum is due to reflection. He suggested that spectral type of the secondary was F8 or later. Popper questioned whether the secondary spectrum is visible at all. Mannino also analyzed his light curves using the Russell-Merrill method and found that the secondary component contributes only one quarter of the total light. Cester et al. (1979) obtained a set of times of minima. They gave quadratic light elements, and suggested that the period is slightly increasing. Sezer et al. (1985) calculated new light elements using all available times of minima. The O-C residuals show a parabola. Holmgren (1988) obtained a new spectroscopic orbit. Photoelectric observations and light curves analysis of GO Cygni have been made by Rovithis et al. (1990), Sezer et al. (1993), Wolf and Diethelm (1992), Oprescu et al. (1996), Edalati & Atighi (1997), Rovithis et al. (1997), Oh & Ra (1998), Oh et al. (2000), Agerer & Hubsher, (2001), and Zabihinpoor et al. (2003).

III. PERIOD STUDY

The first ephemeris formula for GO Cygni was that of Szczyrbak (1932), in which its period had been found equal to $0^d.717767$. Later, Purgathofer and Prochazka (1967), showed that the period of GO Cygni is variable; actually they found that the period had decreased and become equal to 0d.71776382 (regarding only the linear light elements). One can also find two more ephemerides for GO Cygni, in which its period appears to continue its decreasing, being equal to $0^d.7177632$ (e.g. Krakow No., 54, 1983) or $0^d.7177626$ (e.g. Kukarkin et al. 1969). However Sezer et al. (1985) found that after JD 2435600, the period of GO Cygni started to increase ($\triangle$ P $\simeq 0^s.99 \pm 0^s.11$ per century). Hall and Louth (1990) discusses several earlier period studies and fits a quadratic ephemeris to a data set including all photoelectric observations published to that time. Based upon early visual and photographic observations they suggest that an abrupt period decrease occurred in 1934. Another abrupt decrease was suggested by Hall and Louth as possibly occurring in 1984, based upon several times of minimum from Rovithis-Livaniou and Rovithis (1985). Quester (1991) and Goss et al. (1993) dismiss the suggested 1984 decrease based on three new times of minimum. Jones et al. (1994) improved the quadratic ephemeris of Purgathofer & Prochazka, but they have not taken into account all minima times considering many of them as discordant; and they found a periodicity of 37.8 years. Edalati & Atighi (1997) showed that the period of the system, continued its increasing. Oh et al. (1998), used their new times of minimum together with previously published times of minimum lights, to study the period behavior of the system; a continuous period increase of 1.51×10^{-7} day/year was estimated for the quadratic light element. We noticed that most of the previous period studies depend on a limited observational data, where Hall& Louth (1990), used data from 1963 (his own observations) to 1985, Jones et al. (1994) based their study on data from 1939 to 1993, Edalati & Atighi (1997), used the same data together with their new observations, while Oh et al. (1998); Oh et al. (2000) studied the period variation of the star using their new observed times of minima and published minima from 1993. All these previous studies calculated a new period, rate of period change and new light elements, in the present paper we studied and updated the orbital period of GO Cyg by using a more complete data set, from 1932 to 2003, from its (O-C) diagram (Fig. 2), based on 118 minima times found in the literature (Table 1). In the residuals (O-C), the C's have been calculated using Purgathofer & Prochazka (1967) ephemeris:

$$MinI = 2433930.40561 + 0^d.71776382 \times E \quad (1)$$

It can be seen from Figure 1 that the period of the system started to increase after 2435600 which confirms the result of Sezer et al. (1985). The following linear and quadratic light elements:

$$MinI = 2433930.41751 + 0^d.71776521 \times E \quad (2)$$

and

$$MinI = 2433930.40503 + 0^d.71776328 \times E + 0.126 \times 10^{-9} \times E^2 \quad (3)$$

Respectively were calculated. The linear fit shows a period increase of about 0.12 second with respect to Purgathofer & Prochazka (1967). The period increase resulting from these elements is $dP/dE = 2.52 \times 10^{-10}$ day/cycle or 1.282×10^{-7} day/year or 1.11 second/century. This result confirms the parabolic variation indicating a continuous increase of the orbital period suggested by Sezer et al. (1993) and Jones et al. (1994).

TABLE 1. TIMES OF MINIMUM LIGHTS FOR GO CYG.

JD	E	(O-C)	Ref.
2426112.539	-10892	0.0169	Beyer (1936)
2426120.424	-10881	0.0065	Iwanowska & Dziewulski (1932)
2426509.467	-10339	0.0215	Szczyrbak (1932)
2426540.327	-10296	0.0177	Kukarkin (1932)
2426711.145	-10058	0.0079	Kordylewski (1933)
2426957.355	-9715	0.0249	Warmbier (1938)
2427058.553	-9574	0.0182	Dziewulski (1936)
2427140.375	-9460	0.0151	Dziewulski (1936)
2427325.561	-9202	0.0181	Dziewulski (1936)
2427330.589	-9195	0.0217	Dziewulski (1936)
2427417.433	-9074	0.0163	Dziewulski (1936)
2428035.431	-8213	0.0196	Micaika (1939)
2428398.612	-7707	0.0122	Pierce (1939)
2428418.708	-7679	0.0108	Pierce (1939)
2428797.688	-7151	0.0115	Pierce (1939)
2428807.744	-7137	0.0188	Pierce (1939)
2428823.529	-7115	0.0129	Pierce (1939)
2428838.604	-7094	0.0149	Pierce (1939)
2433111.439	-1141	0.0019	Piotrowski & Strzalkowski (1951)
2433483.957	-622	0.0005	Szafraniec (1962)
2433496.878	-604	0.0017	Popper (1957)
2433539.944	-544	0.0019	Kaho (1952)
2433861.499	-96	-0.0010	Ovenden (1954)
2433930.406	0	0.0004	Kwee (1958)
2434309.386	528	0.0011	Kwee (1958)
2434516.818	817	-0.0007	Fitch (1964)
2434606.539	942	-0.0001	Kwee (1958)
2434923.786	1384	-0.0047	Koch et al. (1962)
2436782.442	3973.5	0.0019	Mannino (1963)
2437147.423	4482	-0.0001	Purgathofer & Widorn (1964)
2437189.417	4540.5	0.0048	Purgathofer & Widorn (1964)
2437882.414	5506	0.0008	Mannino (1963)
2437887.438	5513	0.0005	Mannino (1963)
2437888.516	5514.5	0.0018	Mannino (1963)
2437910.406	5545	0.0001	Mannino (1963)
2438242.731	6008	0.0004	Hall & Louth (1990)
2438260.677	6033	0.0023	Hall & Louth (1990)
2438268.567	6044	-0.0031	Hall & Louth (1990)
2439757.574	8118.5	0.0028	Hall & Louth (1990)
2441540.499	10602.5	0.0025	Cester et al. (1979)
2441543.376	10606.5	0.0084	Cester et al. (1979)
2441595.410	10679	0.0046	Cester et al. (1979)
2441608.332	10697	0.0068	Cester et al. (1979)
2441895.434	11097	0.0033	Cester et al. (1979)
2442210.535	11536	0.0059	Cester et al. (1979)
2442714.408	12238	0.0088	Cester et al. (1979)
2443677.649	13580	0.0107	Hall & Louth (1990)
2443702.771	13615	0.0109	Hall & Louth (1990)
2443785.679	13730.5	0.0173	Hall & Louth (1990)
2443790.694	13737.5	0.0079	Hall & Louth (1990)
2443795.721	13744.5	0.0106	Hall & Louth (1990)
2443807.570	13761	0.0165	Hall & Louth (1990)
2443822.639	13782	0.0124	Hall & Louth (1990)
2443833.758	13797.5	0.0061	Hall & Louth (1990)
2444075.293	14134	0.0136	Hall & Louth (1990)
2445866.484	16629.5	0.0249	Sezer et al. (1985)
2445874.376	16640.5	0.0215	Sezer et al. (1985)
2445954.408	16752	0.0229	Sezer et al. (1985)
2445972.353	16777	0.0238	Sezer et al. (1985)
2445982.401	16791	0.0231	Sezer et al. (1985)
2446264.479	17184	0.0199	Rovithis & Rovithis (1985)
2446325.489	17269	0.0199	Rovithis & Rovithis (1985)
2446327.279	17271.5	0.0156	Rovithis & Rovithis (1985)
2446328.359	17273	0.0189	Rovithis & Rovithis (1985)
2446329.428	17274.5	0.0113	Rovithis & Rovithis (1985)
2446351.333	17305	0.0245	Isles (1988)
2446712.373	17808	0.0293	Isles (1988)
2447470.339	18864	0.0367	Isles (1991)
2447762.471	19271	0.0388	Isles (1992)
2447802.311	19326.5	0.0429	Rovithis et al. (1993)
2448016.561	19625	0.0404	Quester (1991)
2448043.479	19662.5	0.0423	Hubscher et al. (1991)
2448176.273	19847.5	0.0499	Rovithis et al. (1993)
2448177.342	19849	0.0423	Quester (1991)
2448194.568	19873	0.0419	Goss et al. (1993)
2448449.381	20228	0.0488	Hubscher et al. (1992)
2448459.426	20242	0.0452	Wolf & Diethelm (1992)
2448460.504	20243.5	0.0465	Hubscher et al. (1992)
2448474.498	20263	0.0441	Jones et al. (1994)
2448475.574	20264.5	0.0435	Jones et al. (1994)
2448479.521	20270	0.0428	Wolf & Diethelm (1992)
2448484.547	20277	0.0444	Jones et al. (1994)
2448496.389	20293.5	0.0433	Wolf & Diethelm (1992)
2448524.382	20332.5	0.0435	B.B.S.A.G. (1991)
2448839.844	20772	0.0483	Jones et al. (1994)
2448844.511	20778.5	0.0499	Hubscher et al. (1993)
2448855.258	20793.5	0.0304	Jassur & Puladi (1993)
2448856.335	20795	0.0308	Jassur & Puladi (1993)
2448862.812	20804	0.0479	Jones et al. (1994)
2449239.645	21329	0.0549	Jones et al. (1994)
2449264.763	21364	0.0511	Jones et al. (1994)
2449267.631	21368	0.0481	Jones et al. (1994)
2449467.532	21646.5	0.0519	Hubscher et al. (1994)
2449555.459	21769	0.0528	Agerer & Hubscher (1995)
2449556.535	21770.5	0.0522	Agerer & Hubscher (1995)
2449605.345	21838.5	0.0542	Rovithis et al. (1993)
2449623.290	21863.5	0.0551	Rovithis et al. (1993)
2449647.333	21897	0.0530	Agerer & Hubscher (1996)
2449907.525	22259.5	0.0556	Agerer & Hubscher (1996)
2449927.258	22287	0.0501	Edalati & Atichi (1997)
2449945.564	22312.5	0.0532	Edalati & Atichi (1997)
2449990.430	22375	0.0589	Martignoni (1996)
2450285.427	22786	0.0549	Vukasovic (1997)
2450397.399	22942	0.0558	Agerer & Hubscher (1998)
2450400.989	22947	0.0570	Oh et al. (2000)
2450409.958	22959.5	0.0539	Oh et al. (2000)
2450428.982	22986	0.0572	Oh et al. (2000)
2450670.509	23322.5	0.0567	Ogloza (1997)
2450673.382	23326.5	0.0586	Agerer & Hubscher (1998)
2451385.405	24318.5	0.0599	Agerer & Hubscher (2001)
2451806.373	24905	0.0595	Agerer & Hubscher (2002)
2452144.442	25376	0.0617	Agerer & Hubscher (2002)
2452518.395	25897	0.0597	Zabihinpoor et al. (2003)
2452530.241	25913.5	0.0626	Zabihinpoor et al. (2003)
2452553.210	25945.5	0.0632	Zabihinpoor et al. (2003)
2452577.254	25979	0.0621	Zabihinpoor et al. (2003)

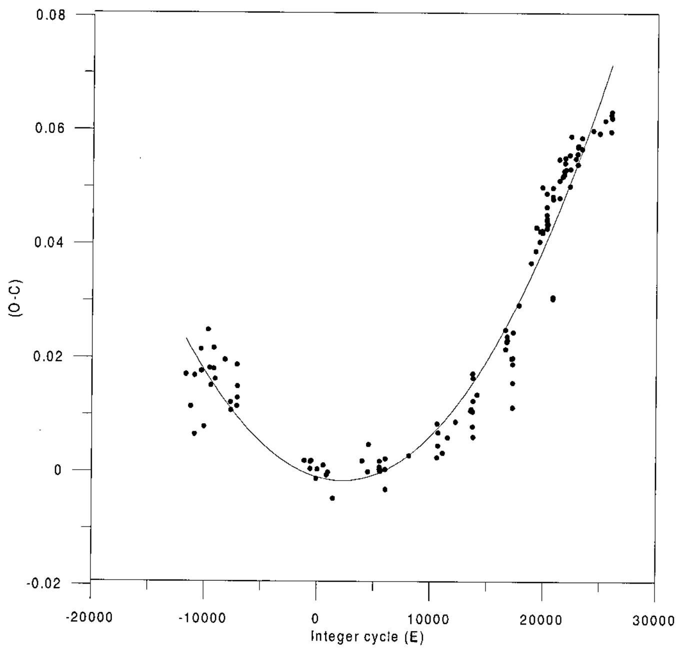

Fig. 1.— Period behavior of GO Cyg defined by photoelectric data. Residuals determined from ephemeris given by Purgathofer & Prochazka (1967).

Meanwhile, our quadratic light element provides additional confirmation for the conclusion reached first by Quester (1991) and later by Goss et al. (1993) that the 1984 period decrease suggested by Hall & Louth (1990), did not occur. We find also that the gross behavior of the system continues to increase the period that increases at nearly a constant rate. The collected light elements together with our new elements are listed in Table 2.

TABLE 2.
THE LIGHT ELEMENTS OF GO CYG.

JD	Period	Quadratic term	Ref.
2426509.467	0.717767		Szczyrbak (1932)
2433930.40561	0.71776382		P & P (1967)*
2433930.40614	0.71776314	$0.108 \times 10^{-9} \times E^2$	P & P (1967)*
2433930.4055	0.71776434		Cester et al. (1979)
2433930.4061	0.71776707		Cester et al. (1979)
2445865.4056	0.71776707		Sezer et al. (1985)
2433930.4060	0.71776331	$0.113 \times 10^{-9} \times E^2$	Sezer et al. (1985)
2433930.4064	0.7177655		Hall & Louth (1990)
2433930.4064	0.71776294	$0.128 \times 10^{-9} \times E^2$	Hall & Louth (1990)
2433930.4064	0.7177576		Hall & Louth (1990)
2433930.40535	0.71776285	$0.153 \times 10^{-9} \times E^2$	Jones et al. (1994)
2445865.4051	0.71776779	$0.16 \times 10^{-9} \times E^2$	E & A (1997)**
2433930.40399	0.71776297	$0.147 \times 10^{-9} \times E^2$	Oh et al. (2000)
2433930.41751	0.71776521		Present work
2433930.40503	0.71776328	$0.126 \times 10^{-9} \times E^2$	Present work

P & P (1967)*: Purgathofer & Prochazka (1967)

E& A (1997)**: Edalati& Atighu (1997)

IV. CONCLUSION

We have presented a period study for β Lyrae type eclipsing binaries GO Cyg and updated light elements by means of O-C diagram using a more complete data set from 1932 to 2003. We also estimated a new period and calculated new linear and quadratic ephemerides for the system; the period increase resulting from these elements is dP/dE $= 2.52 \times 10^{-10}$ day/cycle or 1.282×10^{-7} day/year or 1.11 second/century. New quadratic light element for GO Cyg provides additional confirmation for the conclusion reached first by Quester (1991) and later by Goss et al. (1993) that the 1984 period decrease suggested by Hall and Louth (1990), did not occur. We find also that the period of the system continues increasing at nearly constant rate.

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