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NEW TIMES OF MINIMUM AND A PERIOD CHANGE OF GO CYGNI

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ABSTRACT

Two colour (B & V) photoelectric observations of EB-type eclipsing binary GO Cyg were carried out for 15 nights during October and December 1996. Three new times of minimum derived from our own observations are presented. With these and previously published times, the period variation is studied, and a continuous period increase of dP/dt $\approx 1.51 \times 10^{-7}$ d/yr is estimated from the quadratic ephemeris.

1. INTRODUCTION

The short-period EB-type eclipsing binary GO Cygni(HD 197728, BD $+34^{o}4095$) has been extensively observed since its discovery by Schneller (1928). Spectroscopic observations of the system were made by Pearce (1933) who classified the spectral type of the primary as B9n and the secondary as A0n. But Pierce (1939) noted that the observed reflection is considerable, and the spectral type of the secondary may well be of type F5 or later. Photoelectric observations of the star were made by Ovenden (1954), Popper (1957), and Mannino (1963). Ovenden analyzed his photoelectric light curves by Russell's method, and suggested that the spectral type of the secondary was F8 or later because of reflection in the secondary. Further photoelectric observations of the system were made by Rovithis *et al.* (1990) and Sezer *et al.* (1985, 1993). derived the light elements and obtained a photometric solution by the method of Wilson and Devinny. Concerning the configuration of the system, they classified it as a reverse Algol semi-detached binary.

Early research on the period variation of the system can be found in Purgathofer & Prochazka (1967), and recent investigations are discussed by Hall & Louth (1990) and Jones *et al.* (1994), who collect all of the published minima in the literature and several earlier period studies. Hall & Louth have suggested the possibility of two abrupt period changes in 1934 and 1984. Meanwhile, Jones *et al.* have mentioned a generally increasing period, and also sinusoidal period variation in the system for the first time.

In this study we present new photoelectric observations of GO Cyg in two colours (B & V), and derive three photoelectic times of minimum. New quadratic light elements in accordance with the O-C diagram were derived.

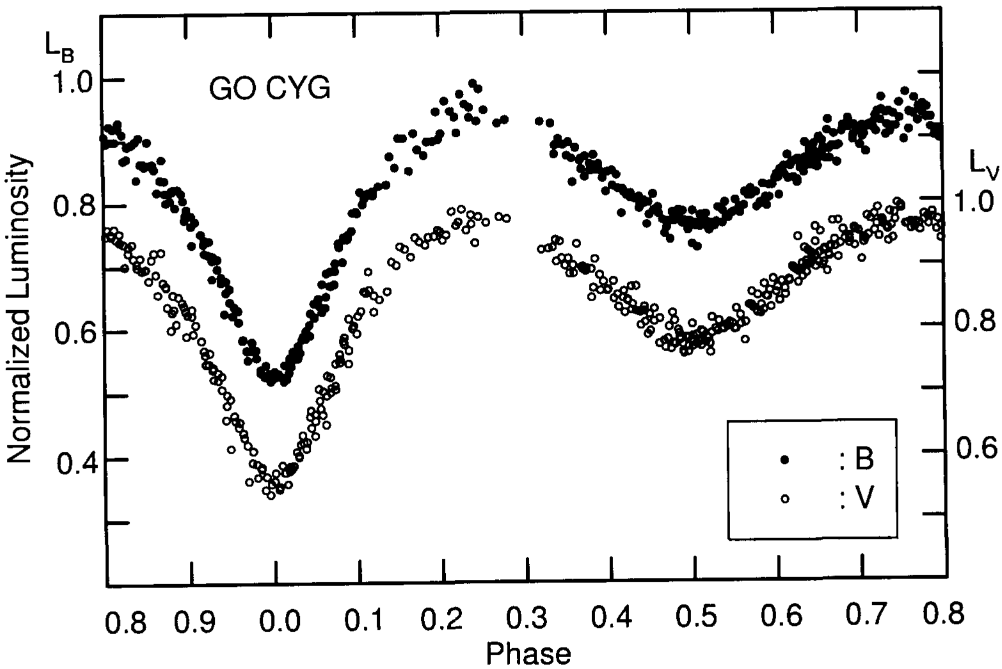

Figure 1. B and V light curves of GO Cyg.

2. OBSERVATION AND TIMES OF MINIMUM

GO Cyg was observed photoelectrically with the 40-cm Cassegrain telescope at Mentor Observatory of Korea National University of Education on 15 nights during October and December in 1996. The observations were made in two colors (blue and yellow) with the use of an uncooled Optec SSP-5 photoelectric photometer and the Johnson standard B & V fiters. BD+35^{o}4197 and BD+35^{o}4098 were observed as comparision and check stars, respectively. The extinction coefficients determined nightly were applied for the correction of differential extinction in each colour.

We obtained 411 individual points of the magnitude differences between the variable and the comparison stars in B, and 409 in V. The yellow and blue light curves are shown in Figure 1, where phases were computed with the following light elements of Sezer *et al.* (1993):

$$Min. I \quad = \quad JD\,Hel. \, 2445865.4056 + 0^{d}_{.}71776707\,E. \qquad (1)$$

Table 1. Times of minimum of GO Cygni.

JD Hel.	Min Type	E	O-C	Method	Ref.
2447802.3114	II	19326.5	0.0433	pe (B,V)	Rovithis *et al.* (1993)
2448043.4720	II	19662.5	0.0353	pe (B)	Hubscher *et al.* (1991)
2448043.4790	II	19662.5	0.0423	pe (V)	Hubscher *et al.* (1991)
2448176.2725	II	19847.5	0.0495	pe (B,V)	Rovithis *et al.* (1993)
2448177.3395	I	19849	0.0398	pe (B)	Hubscher *et al.* (1991)
2448177.3415	I	19849	0.0418	pe (V)	Hubscher *et al.* (1991)
2448180.2189	I	19853	0.0482	pe (B,V)	Rovithis *et al.* (1993)
2448449.3807	I	20228	0.0485	pe	Hubscher *et al.* (1992)
2448460.5035	II	20243.5	0.0460	pe	Hubscher *et al.* (1992)
2448484.5473	I	20277	0.0447	pe	Hubscher *et al.* (1992)
2448844.5110	II	20778.5	0.0499	pe (B)	Hubscher *et al.* (1993)
2448844.5133	II	20778.5	0.0522	pe (V)	Hubscher *et al.* (1993)
2448855.2584	II	20793.5	0.0308	pe (U)	Jassur & Puladi (1993)
2448855.2584	II	20793.5	0.0308	pe (B)	Jassur & Puladi (1993)
2448855.2584	II	20793.5	0.0308	pe (V)	Jassur & Puladi (1993)
2448856.3347	I	20795	0.0305	pe (B)	Jassur & Puladi (1993)
2448856.3345	I	20795	0.0303	pe (V)	Jassur & Puladi (1993)
2449467.5319	II	21646.5	0.0518	pe (V)	Hubscher *et al.* (1994)
2449555.4585	I	21769	0.0523	pe (V)	Agerer & Hubscher (1995)
2449555.4589	I	21769	0.0527	pe (B)	Agerer & Hubscher (1995)
2449556.5353	II	21770.5	0.0524	pe (V)	Agerer & Hubscher (1995)
2449556.5366	II	21770.5	0.0537	pe (B)	Agerer & Hubscher (1995)
2449605.34526	II	21838.5	0.05447	pe (B)	Rovithis-Livaniou *et al.* (1995)
2449605.34585	II	21838.5	0.05506	pe (V)	Rovithis-Livaniou *et al.* (1995)
2449623.29007	II	21863.5	0.05518	pe (V)	Rovithis-Livaniou *et al.* (1995)
2449647.3328	I	21897	0.0528	pe (B)	Agerer & Hubscher (1996)
2449647.3330	I	21897	0.0530	pe (V)	Agerer & Hubscher (1996)
2449907.5249	II	22259.5	0.0555	pe (B)	Agerer & Hubscher (1996)
2449907.5269	II	22259.5	0.0575	pe (V)	Agerer & Hubscher (1996)
2449990.4300	I	22375	0.0589	vi	Martignoni (1996)
2450400.9891	I	22947	0.0571	pe (B,V)	This paper
2450409.9578	II	22959.5	0.0538	pe (B,V)	This paper
2450428.9822	I	22986	0.0574	pe (B,V)	This paper

Two primary and one secondary times of minimum, each of which were the mean of two values determined seperately from our B and V observations, were obtained. These minima are presented in Table 1, together with the times of minima found in the literature since Jones *et al.* (1994). The (O-C) values in Table 1 were computed with the following light elements of Sezer *et al.* (1985) and Hall & Louth (1990) and Jones *et al.* (1994), who discussed the period variation of GO Cyg:

$$Min.\, I \;=\; JD\, Hel.\, 2433930.40561 \,+\, 0\overset{d}{.}71776382\, E. \qquad (2)$$

3. THE (O-C) CURVE AND RESULTS

The (O-C) diagram in Figure 2 has been obtained from all available times of minima published so far, and these (O-C) values computed with Equation 2 are well-fitted by a parabolic curve as

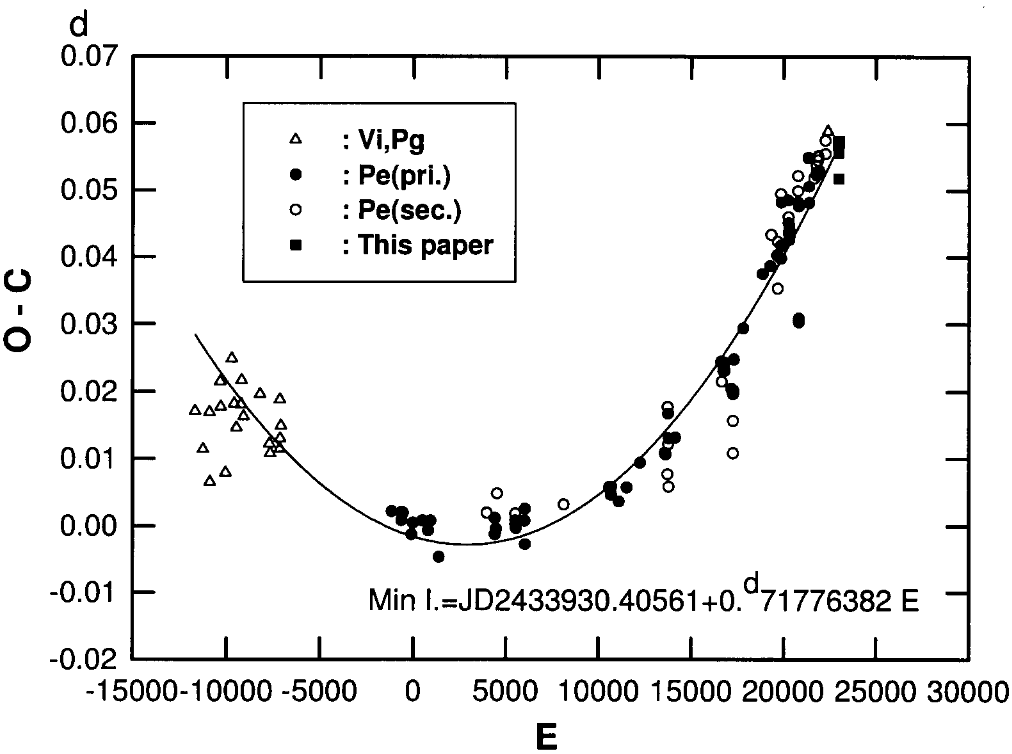

Figure 2. O-C diagram for GO Cyg. The solid line was computed from the new quadratic light elements (Equation 3).

suggested by Sezer *et al.* (1985) and Jones *et al.* (1994). In addition, both primary and secondary times of minima follow the same trend of (O-C) variation. Using all available times of minima including the data in Table 1 and the least-square method, new quadratic light elements were derived as follows:

$$\begin{aligned} Min\, I \;\; = \;\; JD\, Hel.\, 2433930.40399 \; &+ \; 0^{d}\!.71776297\, E \; + \; 0^{d}\!.148 \times 10^{-9}\, E^{2}. \quad (3) \\ \pm .00012 \;\; &\pm .00000022 \qquad \pm .021 \end{aligned}$$

In this calculation, the visual and photographic minima were assigned a weight of *w*=1, while the photoelectric observations were given a weight of *w*=5. Meanwhile, this set of quadratic light elements does not agree with the representation of the period variation as two abrupt period changes, one before JD2427600 and one after JD2446000, as shown by Hall & Louth (1990). Moreover, in 1984, the period decrease they suggested did not occur.

Table 2. The light elements of GO Cyg.

Epoch (+2400000)	Period	Quadratic term	References
26509.467	0.717767		Szczyrbak (1932)
33930.40614	0.71776314	$+0.108 \times 10^{-9} E^{-2}$	Purgathofer & Prochazka (1967)
33930.4060	0.71776331	$+0.113 \times 10^{-9} E^{-2}$	Sezer *et al.* (1985)
33930.4064	0.7177655		Hall & Louth (1990)
33930.4064	0.71776294	$+0.128 \times 10^{-9} E^{-2}$	Hall & Louth (1990)
33930.4064	0.7177576		Hall & Louth (1990)
33930.40399	0.71776297	$+0.148 \times 10^{-9} E^{-2}$	This paper

The (O-C) diagram shows parabolic variation indicating a continuous increase in period. The period increase is found to be about 1.51×10^{-7} d/yr. Except a slightly different rate of period increase, this result is similar to those found by prevoius authors. Finally, the light elements for this system have been modified many times by many authors (see Table 2).

A complete analysis of the observations is being prepared and will appear elsewhere.

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