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PHOTOELECTRIC OBSERVATIONS OF THE PRIMARY ECLIPSE OF AY PERSEI*

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Abstract

UBV observations of the primary eclipse of Algol-type long period eclipsing binary AY Persei have been successfully made using the 61-cm reflector at the Ilsan Station of Yonsei University Observatory in September and October, 1989. These light curves furnish ones to deduce following results; (1)the total duration of the eclipse lasted for about $0^{p}.066$(0.78 days) with no clear evidence of the existence of the totality, (2)the depths of mid-eclipse of $0^{m}.91$ and $1^{m}.07$ for *V* and *B*, respectively, (3)two times of minimum light, JD2447820.203 and JD 2447820.200 for *V* and *B*, respectively, and (4)no period variation with the improved light elements,

$$\text{Min I} = \text{JD } 2427152.237 \underset{\pm 10}{+} 11^{d}.776620 \underset{\pm 4}{E},$$

are made.

I. Introduction

The light variation of AY Persei(BD+50°710) was discovered by Guthnick(Beyer 1934) in 1928. This star was designated as 419.1928 Per. Beyer(1934) confirmed the light variation of this star with the visual observations made during 1929-1934, and deduced the light elements,

$$\text{Min I} = \text{JD } 2427152.27 + 11^{d}.7764E.$$

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Beyer also found that the shape of the light curve of AY Per is an Algol-type with the depth of the primary eclipse $0^m.66$, and $D=0^d.69$ and $d=0^d.11$ for the durations of the eclipse.

Lause(1936) made photographic observations of AY Per during 1934-1936 and obtained 7 times of minima, which are represented by a normal minimum time of JD 2428035.5008. The phase coverage by him is so incomplete that no estimates of D and d are possible.

A complete photographic light curve became available by Gaposchkin(1953) who utilized Harvard plates. His light curve made with an adopted period of $11^d.7764$ shows a constant light level outside eclipse. He suggested the spectral types of two component stars, B9 and F5. The present authors examined his data and deduced $0^m.93$ for the depth of the primary eclipse and $1^d.18$ for the duration of the eclipse, the latter is much longer than that of Beyer and those of others followed by him.

At Sonneberg Lòchel(1960) worked on AY Per with the plates taken during 1927−1959. He obtained 9 times of minima and presented a light curve of large scatter. However, he deduced $D=0^d.71$ comparable with $0^d.61$ of Beyer, but $d<0^d.2$ much larger than Beyer's $0^d.11$.

No radial velocity measurements are so far made for AY Per. Only the spectral type of hotter component is known as AO(Roman 1956), which is significantly later than BO by Cannon(1910).

In any case, AY Per has been left for more than a quarter of a century unobserved since the Sonneberg patrol. The present authors have searched the *Bibliography and the Progress Notes of Binary Stars* for any observation or future planning, but failed. For this reason we have started *UBV* observation in 1983 to secure the eclipse curves. Even though the theoretical chance of the possible eclipse time once or twice a month for each fixed station, only one short night in 1984 furnished us to detect the mid-eclipse part in six years.

In seventh year, this year, we were fortunate enough and made observations of the eclipse of AY Per, full ingress and parts of egress, successfully.

This lead us to report the first photoelectric observations with a hope that this material would stimulates ones for further investigation of this interesting star.

Ⅱ. Light curves and the orbital period

The observation of AY Per in *UBV* using the 0.6M reflector has been carried out since 1983 at the Ilsan Station of Yonsei University Observatory. Up until Spring of 1988 only one short night observation with a large scatter of data in 1984 became available for the detection of the

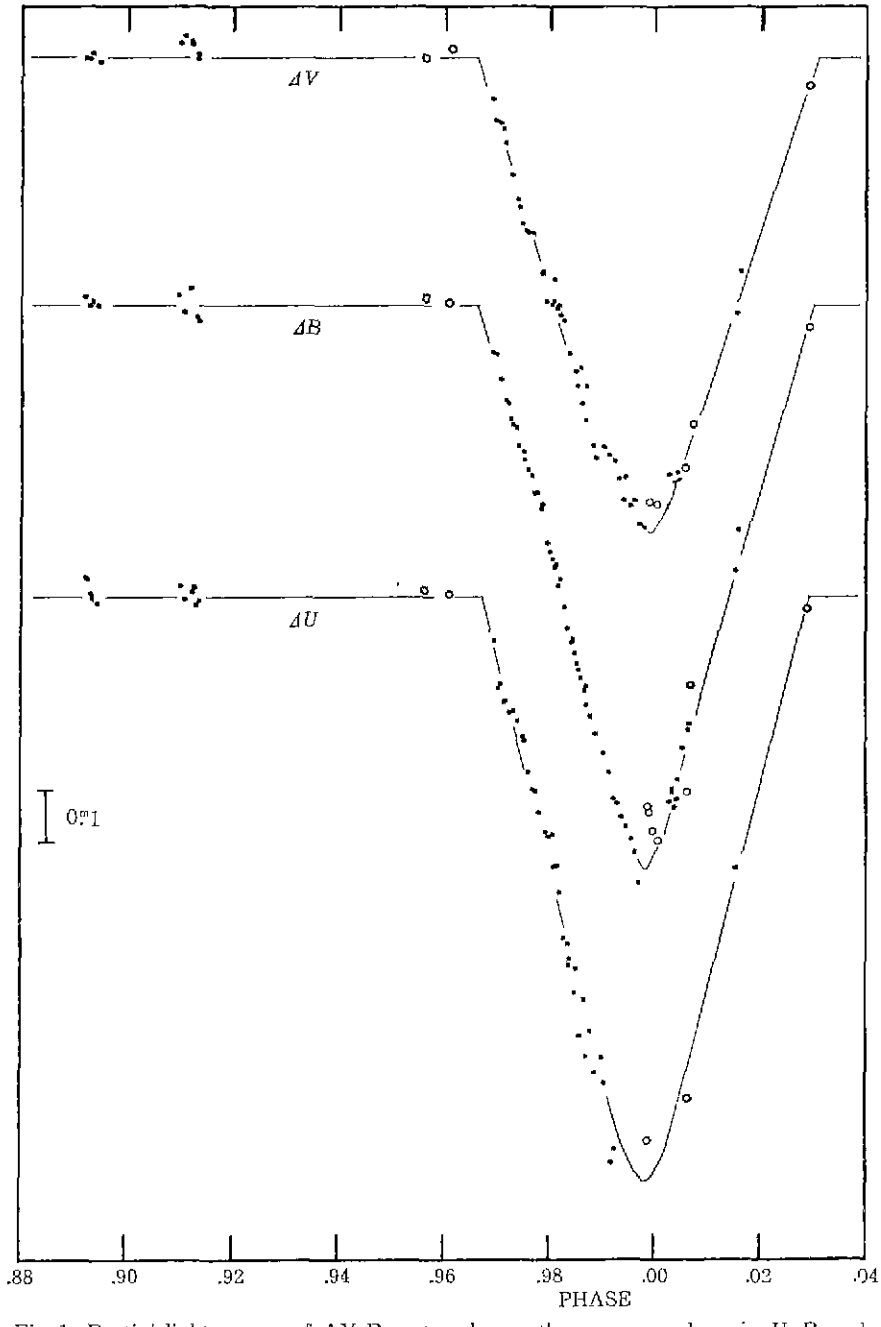

Fig. 1. Partial light curves of AY Per at and near the primary eclipse in *U*, *B*, and *V*(from bottom to upward). Symbols used are open circles and closed circles for the observations in 1984 and 1989, respectively.

primary mid-eclipse. This year, fortunately, furnished us exceptional season for the observations of the primary eclipse, making us to have fairly good coverage of ingress and parts of egress. But the detection of the secondary minimum light is yet left unsuccessful.

With the data of eight nights(3 outside eclipse and 5 eclipse phases) reduced into the instrumental differential magnitude system, Δm(AY Per - comparison star), *UBV* light curves are made and given in Figure 1. The comparison star used is BD+50°706(m_v=7.0, Sp=A2) and the phase are computed with the ephemeris by Lochel(1960),

$$\text{Min I} = \text{JD } 2427152.220 + 11^d.77664E. \quad \cdots\cdots (1)$$

The shape of light curves in Figure 1 may be considered as symmetry, and is shifted only by -0^d.0015 from the expected epoch by the Eq. (1). This phase shift implies that the period of AY Per by Lochel is slightly over-estimated.

Out of five night observations of the eclipse, only the data made on 1989 Oct. 22 suit for the determination of a minimum time, and thus applying a graphical method two minimum times

Table I. Collected and observed times of minimum light of AY Per

Min I (JD 2400000+)	E	O-C_1	O-C_2	W	Meth	Obs*
25303.288	-157	-0^d.060	-0.080	2	Pg	Lo
25502.51	-140	-0.98	-1.00	0	Vi	Gu
25880.42	-108	0.08	-0.06	2	Pg	Be
27152.25	0	0.03	0.01	2	Pg	Be
27717.55	48	-0.05	0.04	2	Pg	Be
28035.5008	75	0.0328	0.0173	3	Vi	La
28565.313	120	-0.104	-0.118	2	Pg	Lo
30367.294	273	0.051	0.040	2	Pg	Lo
30614.553	294	0.001	-0.010	2	Pg	Lo
30991.464	326	0.059	0.049	2	Pg	Lo
33570.420	545	-0.069	-0.075	2	Pg	Lo
36526.543	796	0.118	0.116	2	Pg	Lo
36608.571	803	-0.291	-0.292	2	Pg	Lo
36903.551	828	0.273	0.273	2	Pg	Lo
47820.203	1755	-0.020	-0.002	5	*V*	Th
47820.200	1755	-0.023	-0.005	10	*B*	Th

* Lo=Löchel(1960), Gu=Guthnick(Beyer 1934), Be=Beyer(1934)
La=Lause(1936), Th=This paper

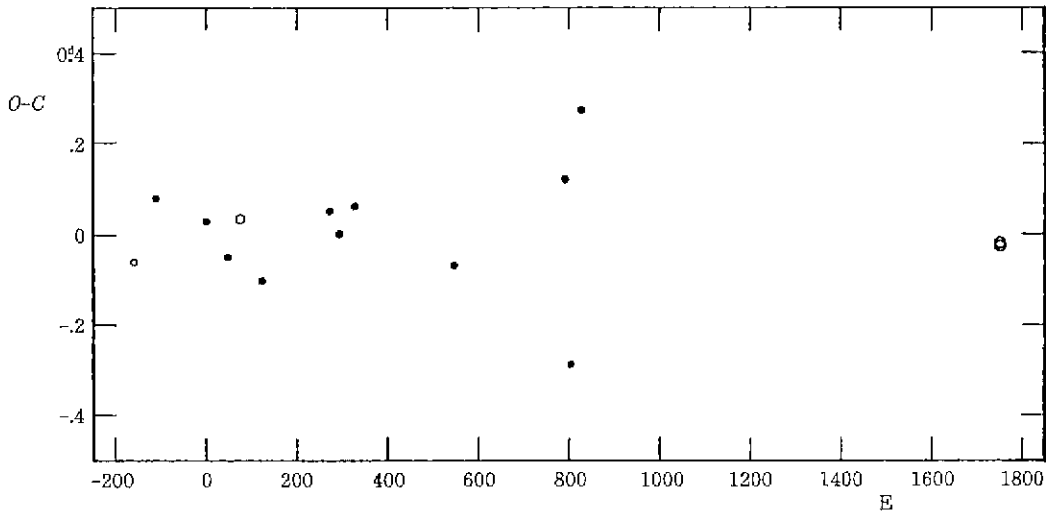

Fig. 2. The *O–C* diagram of AY Per based on the ephemeris of Löchel(1960). Dots represent the visual and photographic observations except Lause's normal point (marked with a small open circle). Two larger open circles are those of the present photoelectric observations.

JD 2447820.203 and JD 2447820.200 are yielded for *V* and *B*, respectively. Times of primary minimum lights are collected, and these with ours are listed in the first column of Table I. The second and third columns of this table represent the number of cycles and the difference, $O-C_1$, between the observation and the computation by the Eq. (1), respectively. With these values an *O–C* diagram is made as shown in Figure 2. Although a large scatter of old observations is present as usual for the cases of visual and photographic data, it is obvious that the orbital period of AY Per remained constant for over 60 years.

In order to refine the period of Lochel, different weights were given as shown in the fifth column of Table I, and the least squares fit conceived new light elements.

$$\text{Min I} = \text{JD } 2427152.237 \underset{\pm 10}{+} 1^{d}.776620 \underset{\pm 4}{E}. \qquad \cdots\cdots (2)$$

The values $O-C_2$ in the fourth column are the results of computation by the Eq. (2).

Ⅲ. Discussions

One of the most interesting topics concerning the eclipse of AY Per system at its early stage of the present investigation would be the presence of the totality at mid-eclipse. The duration D of the primary eclipse of AY Per is rather short among other Algols of well determined, yet the depth variation is large. So that, it is not easy to indentify the totality at the mid-eclipse curves of previously known, although Beyer(1934) and Lochel(1960) claim the totality of longer than 0.1 day, as mentioned in the Introduction. The *UBV* light curves shown in Fig. 1 are not so accurate enough especially at their mid-eclipse for the faintness of AY Per, but the smooth curves which represent the observations show that one would have difficulty of determination of the totality d. It is, on the other hand, possible of the determination of duration D of the primary eclipse in U, B, and V, individually, and found that there is a color dependency; longer with longer wavelength. The collected and present values of D and d are given in Table Ⅱ. Comparing the values of D in this table, it is clear that the present values are slightly larger than those of Beyer and Lochel but significantly smaller than Gaposchkin's. Although the missing of both ingress and egress shoulders makes it difficult in the determination of D in a high precision, the present values are warranted within the error of $\pm 0^{d}.024$.

The second topic of interest is the depth of the primary eclipse light curve of AY Per, because there are large differences among values in Table Ⅱ, ranging from $0.^{m}66$(Beyer 1934) to $1^{m}.05$ (Lause 1936) as given in Table Ⅱ. We do not know at this moment what the exact light level of outside eclipse, and thus average values of three night observations outside eclipse before the

Table Ⅱ. Durations and the depths of the primary eclipse light curves of AY Persei

Observer	Durations		Depth	Method
	D	d		
Beter	$0^{d}.69$	$0^{d}.11$	$0^{m}.66$	Pg
Lause			1.05	Vi
Gaposchkin	1.18		0.93	Pg
Lochel	0.71	<0.2	0.7	Pg
Nha and Kim	0.736	—	>1.1:	*U*
Nha and Kim	0.754	—	1.08	*B*
Nha and Kim	0.765	—	0.91	*V*

primary minimum light are made for U, B and V, under the assumption that the light level outside eclipse were constant. Depths were determined for each bandpath and are listed in Table II together with those of previous investigators. The estimate in U has a large uncertainty, but by the judgement with the shape of U curve one would easily figure the U depth of more than $1^m.1$. The present measurement of the depths in three bandpaths agrees well with the eclipse by a cool component of a large difference in temperature from a hotter one.

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