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LIGHT MAXIMA OF THE DELTA SCUTI STAR HD 94033

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RESUMEN

Observaciones recientes de los tiempos de máximo brillo mediante fotometría fotoeléctrica de la estrella tipo Delta Scuti HD 94033 permiten la determinación de una efemérides para esta estrella de T_{max} = 2442516.15903 + 0.05951012E en concordancia con la derivada anteriormente.

ABSTRACT

Photoelectric photometry of the Delta Scuti star HD 94033 has been carried out. New observations of the maximum light of this star allow a determination of an ephemeris T_{max} = 2442516.15903 + 0.05951012 E in agreement with the previously derived one.

Key words: **VARIABLE STARS – DELTA SCUTI STARS – PULSATION – SX Phe STARS**

I. INTRODUCTION

The Delta Scuti Star HD 94033 was first discovered in 1975 by Przybylski and Bessell (1979, hereinafter PB) in a photometric survey of early type stars with high proper motion; from their observations they concluded that this star shows a period of 85 min 45 s and a visual amplitude of 0.8 mag, from 9.47 to 10.26 mag. In their extensive study on this star, PB found it deficient in metals by a factor of 30 relative to the Sun, and moving around the center of the Galaxy in a highly eccentric and retrograde orbit. According to PB, HD 94033 is the first known short period cepheid which clearly belongs to Population II.

Breger (1977) and Frolov (1974), previous to the report by PB, had already called attention to some Delta Scuti stars that are clearly different and belong to the halo population with high space velocities and low metal abundances, but at that time, the only direct evidence of this rested on the trigonometric parallax and space velocity of SX Phe. With the discovery of NJL 220 (Niss 1981) and NJL 79 (Jorgensen 1982) in the globular cluster ω Cen the membership of this class increased since both have nearly the same physical parameters as SX Phe itself. The complete list of the stars now considered as members of the SX Phe class has been given by Breger and Stockenhuber (1983) and Frolov and Irkaev (1984).

According to Breger (1983), the SX Phe-type variables are not yet explained by stellar evolution theory: they are too hot for the globular cluster main sequence, their radial pulsation periods are too short and their luminosities are several magnitudes too faint for the horizontal branch. Theoretical models developed by different authors lead to different interpretations on their nature. Andreasen (1983) found for the metal poor variables (HD 94033, among them) that their masses $(0.9\text{-}1.3)M_{\odot}$ are consistent with the Pop II Main Sequence hypothesis, but their ages are much less than expected for such objects. Dziembowski and Kozlowski (1974) have developed low mass models that consider degenerate helium cores and represent pre-white-dwarf evolution still governed by hydrogen burning in the shell. Their results, of masses around $0.2\ M_{\odot}$ and a low metal content, predicted a period variation that has been confirmed for CY Aqr by Rolland *et al.* (1984) in a time span of more than fifty three years but, since most of the SX Phe stars have been discovered recently, within the last ten years, a comprenhensive study of their period variation cannot be carried out except for a few of which sufficient amount of observations covering a large basis of time is available. These two facts together encouraged the authors to engage in a study of the monitorying of the time of maximum light of this type of star, since this study will eventually throw light on the characteristics of these stars. In the present paper the determined times of maximum light of HD 94033 are presented.

II. OBSERVATIONS

The observations were carried out mainly in the 1-m telescope of the Observatorio de Tonantzintla, México, with a two-channel high speed photometer (a description of it can be found in Nather and Warner 1971) with an integration every ten seconds. The accuracy with which the maxima were determined is better than 1-min (0.0007 d). A few determinations of the maximum light were carried out at the 0.84-m telescope at the San Pedro Mártir Observatory, México, with one of the original cooled Johnson's photometers in the b filter of the Strömgren System. An integration of the star was obtained every ten seconds and, since only the times of maximum light were desired, the variable alone was monitored with a few observations of a reference star. In consequence, the accuracy of the determined maxima is of 1-min.

III. DISCUSSION

From their 25 times of maximum light that covered a time span of fourteen months, PB were able to determine the following

$$T = 2442516.15836 + 0.0595104212\ E.$$

A new determination of the ephemeris was carried out considering this time, not only PB's determined maxima, but also considering the maxima reported in Table 1 covering, consequently, a time span of nine years. The new determined ephemeris is in excellent agreement with the previously derived parameters by PB and it is the following:

$$T_{max} = 2442516.15903 + (0.05951012 \pm 4 \times 10^{-8}) \times E$$

The uncertainties were derived considering an accuracy in the determination of each maximum of ± 2 min and also taking into account the time span of nine years or 55328 cycles.

Figure 1 presents the residuals of the observed minus calculated time of maximum light versus epoch obtained with the parameters determined in this paper. Unfortunately, no observations known to us, have been carried out on this star since its discovery by PB, and as a result, nothing definitive can be said with respect to the period variation on this star. We plan to continue the observations of these stars and encourage other astronomers to do so, since this is the only way to determine the constancy or variation of their pulsational periods that will, ultimately, lead to a comprehensive knowledge of the nature of these stars.

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TABLE 1

TIMES OF MAXIMUM LIGHT OF HD 94033

	Time of Maximum (HJD 2440000.+)	Epoch	O – C (d)	O – C (min)
1	2516.1585	0	-0.0005	-0.7633
2	2517.9440	30	-0.0004	-0.5524
3	2518.0034	31	-0.0004	-0.5814
4	2518.1223	33	-0.0005	-0.7546
5	2541.9266	433	-0.0004	-0.5213
6	2541.9859	434	-0.0005	-0.7087
7	2542.0448	435	-0.0012	-1.7024
8	2542.1045	436	-0.0010	-1.4290
9	2542.8787	449	-0.0003	-0.4952
10	2542.9382	450	-0.0004	-0.5242
11	2542.9973	451	-0.0008	-1.1580
12	2543.8903	466	-0.0004	-0.5846
13	2544.0094	468	-0.0004	-0.5561
14	2545.9138	500	-0.0003	-0.4897
15	2545.9729	501	-0.0007	-1.0226
16	2562.9930	787	-0.0005	-0.6545
17	2755.2111	4017	-0.0001	-0.1902
18	2846.9767	5559	0.0009	1.3145
19	2847.0959	5561	0.0010	1.5014
20	2847.1550	5562	0.0007	1.0116
21	2890.0628	6283	0.0017	2.4566
22	2890.9553	6298	0.0015	2.1804
23	2891.9664	6315	0.0010	1.4143
24	2929.9939	6954	0.0015	2.1679
25	2958.9161	7440	0.0017	2.5159
26	5748.7479	54320	-0.0008	-1.1786
27	5748.8081	54321	-0.0002	-0.2859
28	5748.8671	54322	-0.0007	-0.9917
29	5748.9278	54323	0.0005	0.7361
30	5748.9861	54324	-0.0007	-1.0353
31	5749.7608	54337	0.0004	0.5465
32	5749.8199	54338	-0.0000	-0.0584
33	5749.8795	54339	0.0001	0.0853
34	5749.9387	54340	-0.0003	-0.3612
35	5750.9503	54357	-0.0003	-0.4506
36	5751.7243	54370	0.0000	0.0080
37	5769.7564	54673	0.0006	0.8340
38	5769.8158	54674	0.0004	0.6135
39	5769.8750	54675	0.0002	0.2189
40	5770.6479	54688	-0.0006	-0.8246
41	5770.7077	54689	-0.0003	-0.4071
42	5770.7674	54690	-0.0001	-0.1336
43	5776.7185	54790	-0.0000	-0.0069
44	5777.6699	54806	-0.0008	-1.1041
45	5777.7303	54807	0.0001	0.1773
46	5782.6699	54890	0.0004	0.5229
47	5782.7294	54891	0.0003	0.4940
48	5782.7890	54892	0.0004	0.6378
49	5782.8485	54893	0.0004	0.6088
50	5783.6812	54907	0.0000	0.0448
51	5783.7410	54908	0.0003	0.3614
52	5783.8000	54909	-0.0002	-0.2320
53	5784.6935	54924	0.0006	0.8771
54	5784.7527	54925	0.0004	0.5169
55	5784.8125	54926	0.0006	0.8191
56	5792.6660	55058	-0.0012	-1.7525
57	5793.6792	55075	0.0003	0.4478
58	5795.6431	55108	0.0004	0.5429
59	5798.6785	55159	0.0008	1.0957
60	5800.6422	55192	0.0006	0.9028
61	5808.6168	55326	0.0008	1.1820
62	5808.6761	55327	0.0007	0.9946
63	5808.7358	55328	0.0009	1.2968

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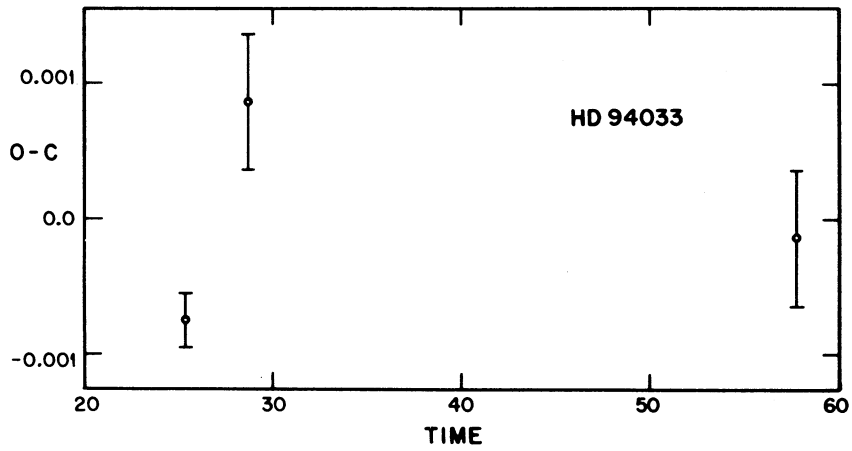

Fig. 1. O–C residuals vs. time diagram for HD 94033. Each point represents a seasonal mean of all the maxima in a time interval of one year. The O–C axis is in day fraction, whereas to convert the time scale into heliocentric julian days one must consider the following: time shown = (HJD–2440000/100).

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