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DISCREPANT PHOTOMETRIC AMPLITUDES IN THE PULSATION OF EN LACERTAE

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RESUMEN

Las efemérides recién publicadas para representar la curva de luz de EN Lac durante los años 1980, no permiten explicar todas las observaciones obtenidas entonces. Las explicaciones más probables pueden ser: variaciones rápidas en la amplitud del tercer período (0.182d), o una imprecisión mayor en las amplitudes publicadas de los dos primeros períodos (0.169 y 0.171d). Si aceptamos los períodos determinados anteriormente, las amplitudes ya publicadas resultan muy dudosas.

ABSTRACT

We show here that recent ephemeris, accounting for the light curve of EN Lac in the 1980's cannot represent all the observations made at that time. Likely explanations can be: either rapid variations in the amplitude of the third period (0.182d), or large imprecisions in the published amplitudes of the two first periods (0.169 and 0.171d). Thus, if we accept the periods previously determined, a serious doubt is raised against the amplitudes published previously.

Key words: **STARS – OSCILLATIONS — STARS – VARIABLES – OTHER**

1. INTRODUCTION

EN Lacertae (16 Lac = HR8725, B2IV) is one of the best known multiperiodic β Cephei variables. In photometry, three large amplitude frequencies are always present in the pulsation, and even 6 more very low amplitude frequencies have been claimed (Jerzykiewicz 1993). A recent summary on the work done so far on 16 Lac is given in Chapellier et al. 1995. Changes in the photometric amplitudes of the three main pulsational frequencies have been found (Fitch 1969; Garrido et al. 1983; LeContel et al. 1983; Jerzykiewicz, Borkowski, & Musielok 1994). We present here some measurements of the amplitudes of the photometric variations of this star obtained years ago, showing that the previous mentioned papers do not describe the whole behavior of the star for the same years.

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2. OBSERVATIONS

EN Lac was observed with the differential photoelectric photometry technique at the Observatorio Astronómico Nacional in San Pedro Mártir, Baja California, México, during the nights of September 11th to 15th 1981 with the 84-cm telescope and also in 1982 (August 19th and 20th) with the 1.5-m telescope. 2 Andromedae (HR8766, A3V) was the comparison star. We used a 1P21 photomultiplier tube cooled with dry ice. The observations were made with an interferential blue filter centered at 4770 Å (see Sareyan, LeContel, & Valtier 1976) and reduced by the GBFOM programs described in Sareyan et al. (1992) (see Table 1).

3. ANALYSIS

1. If we impose on our 1981 data the latest 3 periods and ephemeris (Chapellier et al. 1995), we obtain for the 5 nights of observations the information given in Table 2, where the r.m.s. error on the amplitudes is 3.8 mmag.

Due to the rather small amount of data available —only 5 nights— the adjustment of all 3 imposed periods is quite good, the (O–C) phases being always under 5%. Figure 1 shows the above fit for

TABLE 1

MAGNITUDE DIFFERENCES (16 LAC – 2 AND VERSUS HJD)

HJD	Δm	HJD	Δm	HJD	Δm	HJD	Δm
44858.76711	0.40226	44859.81991	0.40597	44861.82557	0.40677	45200.82960	0.39026
44858.77204	0.39771	44859.82484	0.40269	44861.82759	0.40930	45200.83515	0.39141
44858.77899	0.39533	44859.82755	0.40220	44861.83252	0.40886	45200.83781	0.39413
44858.78100	0.39418	44859.83179	0.41030	44861.83523	0.40625	45200.84071	0.39676
44858.78524	0.40105	44859.83380	0.41058	44861.84016	0.40491	45200.84627	0.39632
44858.78655	0.40189	44859.83873	0.41748	44861.84287	0.40406	45200.85239	0.39750
44858.79079	0.40028	44859.84568	0.41895	44861.84780	0.40768	45200.85599	0.39602
44858.79350	0.39942	44859.84838	0.41438	44861.84981	0.41482	45200.86432	0.39875
44858.79704	0.40033	44859.85401	0.41295	44861.85474	0.41658	45200.86698	0.39840
44858.79836	0.40091	44859.85671	0.40830	44861.85745	0.40974	45200.86988	0.39835
44858.80260	0.39775	44859.86165	0.40694	44861.86932	0.41183	45200.87613	0.40217
44858.80391	0.39819	44859.86435	0.41347	44861.87204	0.41775	45200.87878	0.40354
44858.80746	0.39955	44859.86929	0.41986	44861.87696	0.41522	45200.88307	0.40819
44858.80947	0.39746	44859.87199	0.41664	44861.87898	0.41305	45200.88932	0.41035
44858.81371	0.39466	44859.87623	0.40865	44861.88391	0.41224	45200.89196	0.41271
44858.81572	0.39588	44859.87894	0.41070	44861.88592	0.41047	45200.89488	0.41425
44858.81927	0.39709	44859.88387	0.41642	44861.89155	0.40805	45200.90044	0.41573
44858.82127	0.39703	44859.88658	0.41171	44861.89495	0.41160	45200.90378	0.41814
44858.83177	0.40266	44859.89082	0.40673	44861.89849	0.41383	45200.90599	0.41829
44858.83377	0.40339	44859.89352	0.40719	44861.90051	0.41391	45200.91155	0.41116
44858.83802	0.40329	44859.89845	0.40829	44861.90745	0.40800	45200.91351	0.41106
44858.84002	0.40344	44859.90047	0.40834	44861.91238	0.41190	45200.91641	0.41253
44858.84427	0.40169	44859.90609	0.40552	44862.72837	0.41049	45200.92127	0.41561
44858.84558	0.40157	44860.72278	0.40815	44862.73039	0.41110	45200.92392	0.41244
44858.84982	0.39897	44860.72479	0.41147	44862.73531	0.40955	45200.92752	0.41024
44858.85183	0.40354	44860.72903	0.41071	44862.73872	0.41357	45200.93099	0.41770
44858.86093	0.40737	44860.73104	0.41019	44862.74775	0.41217	45200.93365	0.41752
44858.86294	0.40278	44860.73528	0.41282	44862.76441	0.41411	45200.93585	0.41622
44858.86649	0.40478	44860.73729	0.41235	44862.76934	0.40401	45200.94210	0.41044
44858.87274	0.40026	44860.74354	0.40936	44862.77136	0.40218	45200.94406	0.40805
44858.87475	0.40184	44860.74708	0.41493	44862.77698	0.40416	45200.94696	0.40593
44858.87829	0.40507	44860.74910	0.41641	44862.77969	0.40269	45200.95183	0.40889
44858.88100	0.40624	44860.75403	0.41063	44862.78392	0.40012	45200.95448	0.40715
44858.88524	0.40733	44860.75535	0.40955	44862.78733	0.40132	45200.95738	0.40456
44858.88794	0.40719	44860.75958	0.41704	44862.79156	0.40428	45200.96294	0.40191
44858.89149	0.40678	44860.76514	0.41748	44862.79428	0.40476	45200.96559	0.39924
44858.89350	0.40733	44860.76715	0.41409	44862.79990	0.40000	45200.96780	0.39834
44858.89774	0.40917	44860.77069	0.40793	44862.80261	0.39825	45200.97335	0.39469
44858.89975	0.40921	44860.77410	0.40582	44862.80823	0.40194	45200.97601	0.39206
44859.70678	0.41333	44860.78035	0.40918	44862.81025	0.40343	45200.97891	0.38946
44859.71018	0.41199	44860.78458	0.40970	44862.81587	0.39749	45200.98447	0.38961
44859.71512	0.41123	44860.78660	0.40727	44862.81789	0.39412	45200.98712	0.38638
44859.71782	0.41280	44860.79083	0.40178	44862.82281	0.39264	45200.99002	0.38482
44859.72276	0.41213	44860.79285	0.40097	44862.82483	0.39260	45200.99558	0.38486
44859.72546	0.40605	44860.79708	0.40223	44862.83045	0.39474	45200.99823	0.38340
44859.72970	0.40296	44860.79910	0.40335	44862.83247	0.39655	45201.00113	0.38313
44859.73241	0.39630	44860.80333	0.40326	44862.83740	0.39081	45201.00669	0.38451
44859.74359	0.39030	44860.80535	0.40015	44862.84434	0.39440	45201.00934	0.38313
44859.74630	0.39678	44860.80889	0.39370	44862.84705	0.39285	45201.76020	0.39762
44859.75053	0.39159	44860.81090	0.39286	44862.86233	0.39155	45201.76575	0.39849
44859.75255	0.39629	44860.81514	0.39271	44862.86934	0.39854	45201.76910	0.39976
44859.75748	0.40119	44861.70884	0.40371	44862.87136	0.39981	45201.77200	0.39856

TABLE 1 (CONTINUED)

HJD	Δm	HJD	Δm	HJD	Δm	HJD	Δm
44859.75949	0.39906	44861.72279	0.39416	44862.87698	0.40558	45201.77756	0.40038
44859.76442	0.39758	44861.72550	0.39552	44862.88664	0.40665	45201.78021	0.39948
44859.76643	0.39655	44861.73113	0.40003	44862.89087	0.40477	45201.78242	0.40006
44859.77276	0.38889	44861.74217	0.40013	45200.77821	0.42384	45201.78797	0.40672
44859.77477	0.39143	44861.76863	0.39657	45200.78156	0.42225	45201.79063	0.40500
44859.77901	0.39340	44861.77064	0.40098	45200.78376	0.42319	45201.79284	0.40139
44859.78101	0.38727	44861.78460	0.40414	45200.78932	0.41585	45201.79770	0.40126
44859.78665	0.38919	44861.78662	0.40193	45200.79267	0.40526	45201.80035	0.39872
44859.78935	0.39195	44861.79224	0.39451	45200.79557	0.40479	45201.80811	0.40091
44859.79498	0.39393	44861.79426	0.39335	45200.80447	0.40220	45201.81077	0.40282
44859.79769	0.39987	44861.79988	0.39679	45200.80738	0.39211	45201.81367	0.40205
44859.80262	0.39724	44861.80259	0.39959	45200.81293	0.38624	45201.81853	0.39845
44859.80532	0.39519	44861.80821	0.40630	45200.81559	0.38640	45201.82119	0.40042
44859.80956	0.40248	44861.81092	0.40570	45200.81918	0.38828	45201.82409	0.40528
44859.81227	0.40717	44861.81585	0.39892	45200.82404	0.38282	45201.82895	0.39890
44859.81720	0.40647	44861.82065	0.39920	45200.82670	0.38575	45201.83160	0.40173

TABLE 2

DEDUCED AMPLITUDES AND O–C OF MAXIMA FROM OUR 1981 DATA

Periods (days)	Amplitudes (mmag)	Light maxima HJD-2400000	(O–C) of maxima (days)
P_1=0.1691778	9.1	44858.763	−0.005
P_2=0.1707769	5.6	44858.818	+0.002
P_3=0.1817331	7.5	44858.851	+0.009

the 1981 observations. The only discrepancy from Chapellier et al. (1995) comes from the amplitudes, significantly different from those obtained that same year 1981; they get 7.1, 5.3 and 10.3 mmag at a mean date of JD 2444910, while we obtain here 9.1, 5.6 and 7.5 mmag around JD 2444860. So it seems that the amplitude of P_1 and P_3 might have undergone significant variations in a 50 day interval.

We already know that P_3 may show amplitude variations on a time scale of a few weeks (see Fitch 1969). More surprising is the small decrease (2 mmag) in the amplitude of P_1, although this is close to the precision limit of our data (5 nights, while Garrido et al. 1983, used 9 nights for their amplitude determination).

2. The 1982 data, consisting of only two nights, is rather difficult to analyze by the same procedure used on the 1981 data.

– A strong beat appears on these observations, as 16 Lac does not show any significant variation above the detection threshold on the second night, while on the first one it had a light range over 30 mmag (Figure 2). Only a beat with P_3 can give such a rapid decrease (from one night to the following one) on the total light variation of the star (the beat period between P_1 and P_2 is about 18 days, while it is less than 3 days between P_3 and either P_1 or P_2).

– Thus, on the one hand, the combined amplitudes of P_1 and P_2 must be about that of P_3, with opposite sign, around JD 2445201.8

– On the other hand, as the ephemeris given by Chapellier et al. seem to give a good phasing of our observations in 1981, and are established through 1984, we can impose again the same 3 periods and calculate the corresponding phases on the 1982 data. Doing so, the amplitudes can be deduced, knowing that we will not get such a good precision as for 1981, due to the poor sampling in 1982: at HJD 2445201.8 the phases after maximum for the 3 periods are $\phi_1 = 0.764$, $\phi_2 = 0.374$, and $\phi_3 = 0.151$.

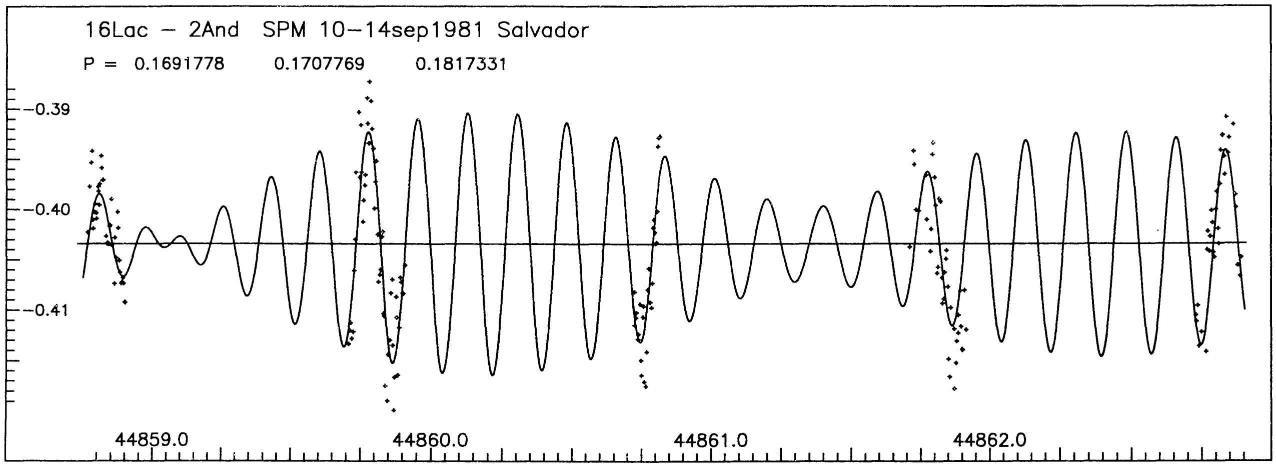

Fig. 1. Observations and predicted light curve for EN Lac in 1981. (Ordinates = EN Lac - 2 And in magnitudes. Light increases upwards).

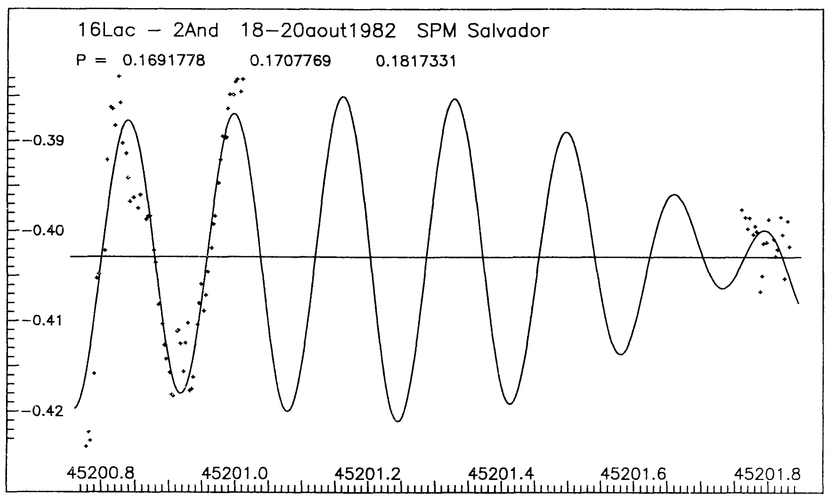

Fig. 2. Observations and predicted light curve for EN Lac in 1982. (Same ordinates as in Figure 1).

From the two considerations above, one can conclude that for JD 2445201.8 the respective amplitudes a_1, a_2, a_3 for the periods P_1, P_2, P_3 are such that

$$0.087\,a_1 - 0.704\,a_2 + 0.582\,a_3 \simeq 0 \ .$$

(Or $\simeq +2.5$ mmag, if we take into account at JD 2445201.8 in Fig. 2 the very small light excess above the zero line. We call here 'zero' line the mean magnitude difference Δm between variable and comparison, as given by the least squares fit. Δm is about 0.403 in our instrumental system and the a_i amplitudes are referred to this 'zero').

If we try to go further, making few assumptions on the amplitudes a_1 and a_2 of P_1 and P_2, we should be able to deduce the actual amplitude a_3 of P_3 for the 1982 data. Any amplitudes taken or interpolated from the available literature for a_1 and a_2 in 1981 (i.e., a_1 from 6.1 to 9.6 mmag and a_2 from 5.1 to 5.6 mmag) can only give for a_3 at HJD 2445201.8 an amplitude around 5 mmag (or 9 to 10 mmag at most if we take the above equation equal to +2.5 mmag).

These amplitudes for P_3 are totally incompatible with the variation range observed one day before (i.e., around JD 2445200.9): about 15 mmag above and below the mean 'zero' of Δm at JD 2445200.83 and JD 2445200.92. At that date, with the same a_1 and a_2 amplitudes, we cannot have any a_3 amplitude smaller than 20 mmag above the 'zero' line (we calculate a_3 amplitudes in the 21 to 28 mmag range).

Thus, if we still assume that the periods did not vary and that the corresponding phases can be calculated accordingly (see Chapellier et al. 1995), the amplitude of P_3 cannot match the published ephemeris:

- Either a_3 itself varies very quickly, i.e., by a factor 2 within one day,
- or the interpolated or adopted values for a_1 or a_2 are mistaken,
- or, less probably, our 1982 data are insufficient to derive a precise amplitude for a_3.

4. CONCLUSION

Our observations confirm that in 1981 and 1982 the three principal known periods for EN Lac were in phase with Chapellier's ephemeris. However, the amplitudes could differ somewhat from those published previously.

The "erratic" —i.e., not simply predictable— behaviour of P_3 appears one more time in the present data. Although the strong beat observed in our 1982 observations does coincide with the ephemeris predictions, a strong uncertainty remains on the amplitude of the third period at that date.

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