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BP PEGASI : 74 TIMES OF MAXIMA, IMPROVEMENT OF THE EPHEMERIS AND EVIDENCE OF VISUALLY OBSERVED BLAZHKO EFFECT

ABSTRACT. BP PEGASI : 74 TIMES OF MAXIMA, IMPROVEMENT OF THE EPHEMERIS AND EVIDENCE OF VISUALLY OBSERVED BLAZHKO EFFECT.

The 0.4 mag amplitud RRs star BP Pegasi has been observed in 1976 and 1977, mainly at the GEOS summer camp of S^t Rome (France) by 7 visual observers.

More than 2400 estimates have been completed leading to the determination of 74 times of maximum.

A significantly negative mean O-C has been found with respect to BROGLIA's ephemeris (P. BROGLIA, 1959). Nevertheless, we still have to assume the constancy of the period since 1953, as our new period and BROGLIA's are consistent within their error bars.

The new derived ephemeris is, for the fundamental period :

(2) Max = Hel. J. D. 24 43 014. 5786 + 0. 109 543 375 E
± 12 ± 25

(error bars at 95% level of confidence)

A good mean curve has been obtained using the 0. 084 510 day period of the 0.1 mag secondary oscillation.

This oscillation has not escaped detection by all of the more productive visual observers, which is an excellent result and a good confirmation of BROGLIA's determination of the beat period.

RESUME. BP PEGASI : 74 INSTANTS DE MAXIMUMS, AMELIORATION DE L'EPHEMERIDE, ET DETECTION VISUELLE DE L'EFFET BLAZHKO.

BP Pegasi, variable de type RRs et d'amplitude 0,4 magnitude, a été observée en 1976 et 1977, principalement au camp d'été du GEOS à S^t Rome (France), par 7 observateurs visuels.

Plus de 2400 estimations ont été effectuées, permettant la détermination de 74 instants de maximums.

L'O-C moyen est négatif, de façon significative, relativement à l'éphéméride de référence (P. BROGLIA, 1959). Cependant, il n'est pas nécessaire d'abandonner l'hypothèse de la constance de la période (depuis 1953), car notre nouvelle valeur de période et celle de BROGLIA demeurent compatibles à l'intérieur de leurs bandes d'erreur.

L'éphéméride améliorée devient donc, pour la période fondamentale :

(2) Max = J.J.hél. 24 43 014, 5786 + 0, 109 543 375 E
± 12 ± 25

(bandes d'erreur au niveau de confiance 95%)

Par ailleurs, une bonne courbe moyenne visuelle a été obtenue sur la période 0, 084 510 j de l'oscillation secondaire, qui a un dixième de magnitude d'amplitude.

Cette oscillation a été détectée par tous les observateurs visuels les plus productifs, ce qui est un excellent résultat, ainsi qu'une bonne confirmation de la détermination de la période de battement par BROGLIA.

RIASSUNTO. BP PEGASI : 74 ISTANTI DI MASSIMO, MIGLIORAMENTO DELL'EFFEMERIDE E DETEZIONE VISUALE DELL'EFFETTO BLAZHKO.

BP Peg, variabile tipo RRs d'ampiezza 0,4 mag, è stata seguita da 7 osservatori visuali nel 1976 e 1977, principalmente al campo d'estate del GEOS a S^t Rome (Francia). Sono state effettuate più di 2400 stime, con la conseguente determinazione di 74 istanti di massimo.

L' O-C medio è significativamente negativo in relazione all'effemeride di riferimento (P. BROGLIA, 1959). Non è tuttavia necessario abbandonare l'ipotesi della costanza del periodo (dal 1953), dato che il nostro valore e quello di BROGLIA sono compresi nelle rispettive bande d'errore.

Il miglioramento dell'effemeride conduce, per il periodo fondamentale, a :

(2) Max = G.G.elioc. 24 43 014, 5786 + 0, 109 543 375 E
± 12 ± 25

(barre d'errore al livello di confidenza del 95%)

Inoltre è stata ottenuta una buona curva visuale media sul periodo 0, 084 510 d dell'oscillazione secondaria, che ha l'ampiezza di 0,1 mag.

Quest'oscillazione è stata evidenziata da tutti gli osservatori che hanno seguito a lungo la stella, cio che costituisce un eccellente risultato per le osservazioni visuali cosi come una conferma della determinazione di BROGLIA riguardo al periodo dei battimenti.

RESUMEN. BP PEGASI : 74 INSTANTES DE MAXIMOS, MEJORA DE LA EFEMERIDE Y DETECCION VISUAL DEL EFECTO BLAZHKO.

BP Pegasi, variable de tipo RRs y de amplitud 0,4 magnitudes, fué observada en 1976 y 1977, principalmente en el campo de verano del GEOS en S^t Rome (Francia) por 7 observadores visuales.

Fueron efectuadas mas de 2400 estimaciones, las cuales permitieron la determinacion de 74 instantes de maximos.

El O-C es negativo, de forma significativa, con respecto a la efeméride de referencia (P. BROGLIA, 1959). Sin embargo, no es necesario abandonar la hipotesis de la constancia del periodo (que data de 1953) pues nuestro nuevo valor del periodo y el de BROGLIA continuan siendo compatibles dentro de sus bandas de errror.

La efeméride mejorada queda pues asi para el periodo fundamental :

(2) Max = Hel. J. D. 24 43 014, 5786 + 0, 109 543 375 E
± 12 ± 25

(barras de error con un nivel de confianza del 95%)

Por otra parte, ha sido obtenida una buena curva media visual sobre el periodo 0, 084 510 d de la oscilacion secundaria, que tiene una décima de magnitud de amplitud.

Esta oscilacion ha sido detectada por todos los observadores visuales mas productivos, lo que es un excelente resultado, al mismo tiempo que una buena confirmacion del periodo de batimiento por BROGLIA.

1. INTRODUCTION

BP Pegasi, with coordinates 1950.0: α = 21 h 31 m 00 s, δ = + 22° 31'.3, is an RRs-type variable, spectrum A5 - F0, mean range 11.81 to 12.23 V, M-m = 0.30.

The fundamental period P_0 of the light variation is given by the following ephemeris:

$$(1) \qquad \text{Max} = \text{Hel. J.D. } 24\,34\,600.5520 \pm 7 \quad + \; 0.109\,54\,347 \pm 5 \quad E \quad \text{(mean error)}$$

Ephemeris (1) was derived by P. BROGLIA from extensive photoelectric photometry carried out at the MILANO-MERATE Observatory in 1953 and 1958-59 (A. MASANI and P. BROGLIA, 1954 ; P. BROGLIA, 1959).

BROGLIA was able to prove the presence of a Blazhko effect with a slightly variable beat period P_b: P_b = 0.3720 d in 1953 and P_b = 0.3698 d in 1958-59. The beat phenomenon causes the O-C's to vary within ± 0.003 d and the magnitude of the maxima within ± 0.045 mag in V and ± 0.07 mag in B, as referred to the fundamental oscillation (1).

Besides, BROGLIA pointed out a probable shortening of the period P_0 before 1953, mainly on the grounds of a discrepancy with the epoch of KUKARKIN's ephemeris (B.V. KUKARKIN, 1938) in relation to (1).

2. OBSERVATIONS

BP Pegasi was visually observed at the GEOS 1976 summer camp of ST ROME (Lozère, France), simultaneously with two other RRs stars. The instrument assigned to BP Peg was a 256-mm telescope (at 57x magnification).

Figure 1 gives the identification chart. Approximate v magnitudes for the three most important comparison stars are: A = 11.1 B = 11.8 D = 12.7.

2211 visual estimates were made by 8 observers from 1976 August 18 to 1976 September 01 (see Table 1).

214 further estimates (69 made in 1976 October and 145 in 1977 September) were made by the author in Paris, after the ST ROME camp, using the same telescope:

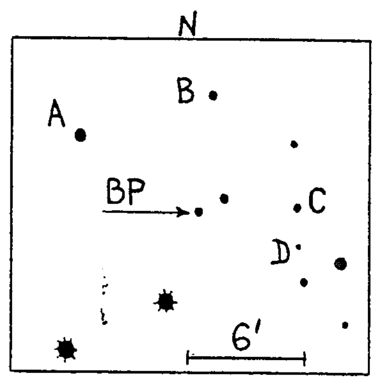

Fig. 1. Field of BP Pegasi.

Observers		Identification	Origin	Number of estimates
Alain	FIGER	FGR	F - Paris	569
Jean-François	LE BORGNE	FLB	F - Brest (*)	412
Pascal	GUIRAUDOU	GUI	F - Montgeron	368
Claudio	ROMOLI	RML	I - Altopascio	326
Philippe	RALINCOURT	RAL	F - Nantes	306
Alain	ROYER	ROY	F - Epinac	155
Alain	MAROT	MAR	F - Quimper	41
Nicola	ZACCARIA	ZCR	I - Pisa	34

(*) Now at the Pic-du-Midi and Toulouse Observatory

Table 1. ST ROME Camp : List of the observers of BP Pegasi. The 2211 observations were made from 1976 AUG 18 to 1976 SEP 01.

3. DISCUSSION

3.1 List of the observed maxima

The times of the 63 maxima observed at ST ROME 76 are listed in Table 2. They were derived from the individual light curves by several GEOS members, using manual smoothing. The 11 additional maxima observed at PARIS are listed in Table 3.

3.2 Determination of a mean O-C

The O-C's in Tables 2 and 3 are referred to ephemeris (1). A systematic negative trend appears in both cases. There is no significant difference between the results obtained in 1976 and those obtained in 1977. Consequently, the arithmetic mean for all the O-C's is : O-C = - 0.0073 d ± 0.012 d. The error on the mean O-C is expressed at a 95% level of confidence.

The standard deviation of the 74 individual O-C's is : s(O-C) = 0.0053 d , that is : 7.6 mn (and 4.8 % of the period length).

Weighting the data (see for example E. PORETTI, 1981 ; Ph. RALINCOURT, 1982) does not bring here any decisive improvement as they are rather homogeneneous and the weighted mean O-C is very similar to the unweighted one.

3.3 Ascertaining of the period

Between our mean maximum, at Hel.J.D. 24 43 014. 5786 ± 0. 0012 , and the epoch of BROGLIA's ephemeris, we find an interval of 8414. 0266 d ± 0. 0018 d for 76 810 elapsed cycles.

The mean period over 23 years :	P_o = 0. 109 543 375	d	
	± 25		(at 95%)
can compare with BROGLIA's period :	0. 109 543 47	d	
	± 10		(at 95%)

Both periods are equal within a 95 % confidence interval.

As a consequence, our significative O-C does not necessarily imply a new shortening of BP Peg's period. On the contrary, we still have to assume the constancy of the period since 1953.

On the other hand, the slight improvement of BROGLIA's period does not alter his statement concerning a probable shortening before 1953.

3.4 Investigation on the Blazhko effect

It is not unreasonnable to look for a visually observed Blazhko effect as the secondary oscillation exhibits a 0.09 V-magnitude amplitude (according to BROGLIA , 1959).

However, as our basic data, the visual estimates, are rather inaccurate, they might fail to evidence the periodic variation of O-C's and height of maxima. In that way indeed, only a part of the visual estimates, i.e. those around the times of maximum are taken in account.

It is of importance to use all the information, and plotting a mean curve on the secondary period is the way to it ; with visual estimates with a standard deviation of 0.01 mag, calculating means on batches of 10 to 20 measures will give an adequate signal-to-noise ratio.

Figure 2 shows the mean curves obtained by the 5 most productive observers (FGR, FLB, GUI, RML, RAL). For each observer we have plotted two mean curves using two periods : P_o the fundamental, and P_1 = 0. 084 510 d the secondary one. P_1 is derived from the formula : $1/P_1 = 1/P_b + 1/P_o$ where P_o = 0. 109 543 47 d and P_o = 0. 3698 d.

A remarkable result is found, as a significative oscillation for P_1 is present on the mean curves of all 5 observers.

To test the reality of the phenomenon, 3 curves have been computed in another way : when subtracting the fundamental oscillation from the data, the result does not change much (as a rule, the shape of the curve is kept and the amplitude decreases a little).

Table 4 summarizes the main characteristics of the mean curves.

Date AUG 76	Geoc. U.T.	Hel. J. D. 24 43 000 +	O-C (day)	Obser-ver
18	22:10.	9.4283	−0.0091	ROY
19	00:44.	9.5353	−0.0116	FGR
19	03:15.4	9.6404	−0.0161	ROY
19	03:23.4	9.6460	−0.0105	FGR
19	03:29.8	9.6504	−0.0061	FLB
19	21:47.4	10.4126	−0.0107	ROY
19	21:48.2	10.4132	−0.0101	FGR
19	21:55.3	10.4181	−0.0052	GUI
19	21:58.5	10.4203	−0.0030	RAL
19	22:00.	10.4214	−0.0019	FLB
19	22:00.5	10.4217	−0.0016	RML
20	00:32.9	10.5275	−0.0053	FGR
20	00:44.	10.5353	+0.0025	GUI
20	21:25.	11.3971	−0.0121	GUI
20	21:32.	11.4019	−0.0073	RML
20	21:33.5	11.4030	−0.0062	RAL
20	21:34.8	11.4039	−0.0053	FLB
20	21:38.8	11.4066	−0.0026	FGR
20	23:58.5	11.5037	−0.0150	GUI
21	00:03.8	11.5073	−0.0114	RAL
21	00:09.2	11.5111	−0.0076	FGR
21	00:09.2	11.5111	−0.0076	FLB
21	00:16.3	11.5160	−0.0027	RML
21	02:38.7	11.6149	−0.0134	GUI
21	02:38.9	11.6150	−0.0133	RML
21	02:47.4	11.6210	−0.0073	FLB
21	02:50.7	11.6232	−0.0051	FGR
21	02:53.3	11.6250	−0.0033	RAL
21	21:08.2	12.3854	−0.0097	RAL
21	21:10.8	12.3872	−0.0079	FLB
21	21:28.	12.3991	+0.0040	RML
21	23:47.5	12.4960	−0.0086	RML
21	23:50.2	12.4978	−0.0068	GUI
21	03:51.6	12.4989	−0.0057	FGR
21	23:54.3	12.5007	−0.0039	RAL
22	00:00.	12.5047	+0.0001	FLB
22	02:18.	12.6005	−0.0137	RAL
22	02:21.9	12.6032	−0.0110	FGR
22	02:25.3	12.6056	−0.0086	FLB
24	01:41.	14.5748	−0.0111	FGR
24	01:42.	14.5755	−0.0104	RML
24	02:02.	14.5894	+0.0035	RAL
24	02:08.8	14.5941	+0.0082	FLB
26	01:09.5	16.5530	−0.0047	FLB
26	01:10.2	16.5535	−0.0042	FGR
26	21:46.	17.4116	−0.0225	GUI
26	21:52.6	17.4162	−0.0179	RML
26	22:04.	17.4241	−0.0100	FGR
26	22:13.5	17.4307	−0.0034	RAL
27	00:43.	17.5346	−0.0090	GUI
27	00:43.2	17.5347	−0.0089	RML
27	00:44.	17.5353	−0.0083	FGR
27	03:20.	17.6436	−0.0096	RML
27	03:21.5	17.6446	−0.0086	FGR
27	21:42.	18.4089	−0.0111	GUI
27	21:50.	18.4144	−0.0056	FGR
27	21:50.3	18.4146	−0.0054	RAL
28	00:26.	18.5228	−0.0067	FLB
28	00:28.2	18.5243	−0.0052	GUI
28	00:29.3	18.5250	−0.0045	RAL
28	00:32.7	18.5274	−0.0021	FGR
28	02:58.6	18.6287	−0.0103	FGR
28	03:01.3	18.6306	−0.0084	RAL

Table 2. BP PEG observed at St ROME 76 by 6 observers. 63 times of maxima. The O-C's refer to ephemeris (1).

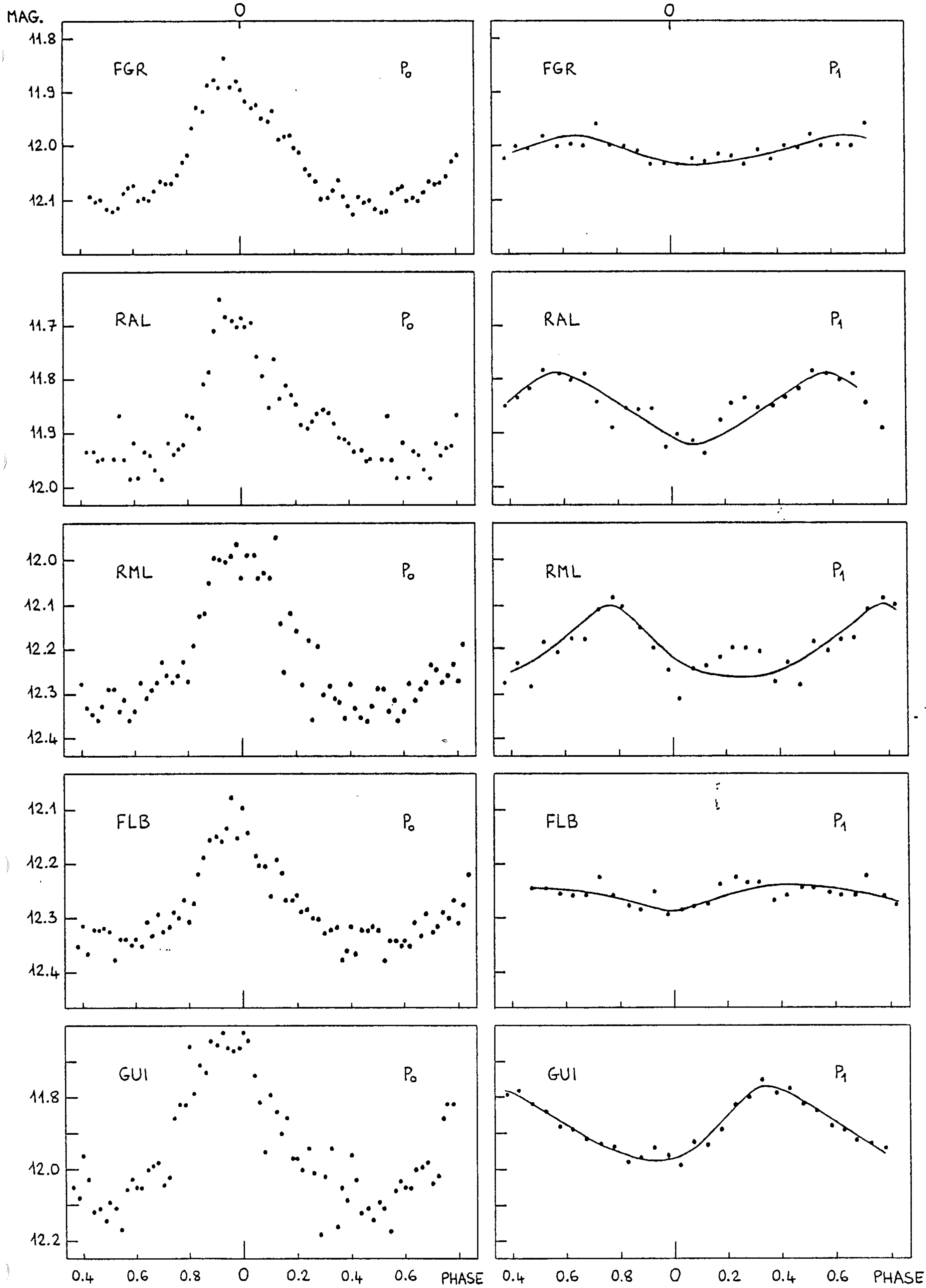

Fig. 2 Mean curves by 5 observers for both periods of BP Pegasi.
Left: fundamental period P_0; ephemeris (1): 34 600.5520 + 0.109 543 47 E. Dots are means on 0.02 period.
Right: secondary period P_1; ephemeris (1'): 34 600.5520 + 0.084 509 705 E. Dots are means on 0.05 period.

Date	Geoc. U.T.	Hel. J. D. 24 43 000 +	O-C (day)
1976 OCT 16	23:22.	68.4767	-0.0046
1976 OCT 17	20:26.5	69.3547	-0.0030
1977 SEP 02	01:21.	388.5610	-0.0063
1977 SEP 05	21:27.	392.3984	-0.0030
1977 SEP 06	00:06.	392.5088	-0.0021
1977 SEP 06	21:04.5	393.3827	-0.0046
1977 SEP 11	00:56.	397.5435	-0.0064
1977 SEP 11	21:53.	398.4164	-0.0099
1977 SEP 13	21:21.8	400.3946	-0.0034
1977 SEP 14	20:39.	401.3649	-0.0190
1977 SEP 14	23:16.	401.4739	-0.0196

Table 3. BP Peg observed at PARIS by FGR. 11 times of maxima. The O-C's refer to ephemeris (1).

Observer	FUNDAMENTAL (P_0)			SECONDARY (P_1)			Amplitude ratio
	Φ MAX	Φ MIN	AMPL.	Φ MAX	Φ MIN	AMPL.	(P_1/P_0) %
FGR	0.935	0.545	0.26 m	0.65	0.07	0.05 m	19
RAL	0.94	0.61	0.30	0.56	0.05	0.13	43
RML	0.965	0.495	0.36	0.76	0.13	0.16	44
FLB	0.95	0.54	0.25	0.42	0.99	0.04	16
GUI	0.93	0.51	0.49	0.34	0.95	0.19	39
Mean	0.944	0.54	0.33 m	0.55	0.04	0.11 m	33 %

Table 4. BP Peg : Phases of maximum and minimum and Amplitudes from light-curves of Figure 2.

Notable discrepancies in phase are apparent at the maximum of the secondary oscillation, whereas a better fit exists at the minimum, thus excluding the hypothesis of a random distribution.

The amplitude ratio of the secondary to the fundamental oscillation is a little higher than expected : 33 % for us, versus 21 % in V and 24 % in B according to BROGLIA.

Clearly, the amplitude of the primary oscillation (0.33 mag) has been under-estimated by the visual observers, as is often the case in visual mean curves (see, for example, A. FIGER, 1982).

The amplitude ratio drops to 27 % when considering the GEOS observers' mean curve plotted after the secondary period in Figure 3.

Figure 4, showing BROGLIA's V mean curve after the secondary period, is a proof of the quality of visual observations. The shape can compare, whereas the shift in phase has no significance for the very long time elapsed between the visual and BROGLIA's observations.

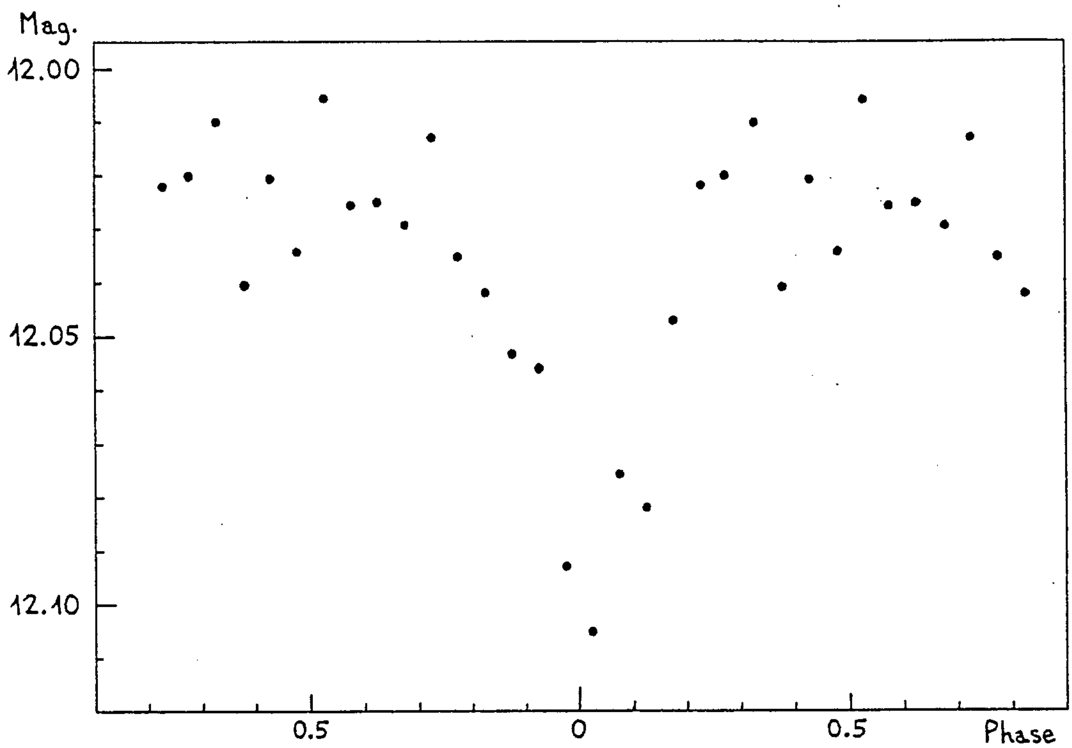

Fig. 3. Mean curve by visual observers FGR, RAL, RML, FLB, GUI, for secondary period P_1 (ephemeris 1'). Dots are means on 0.05 period.

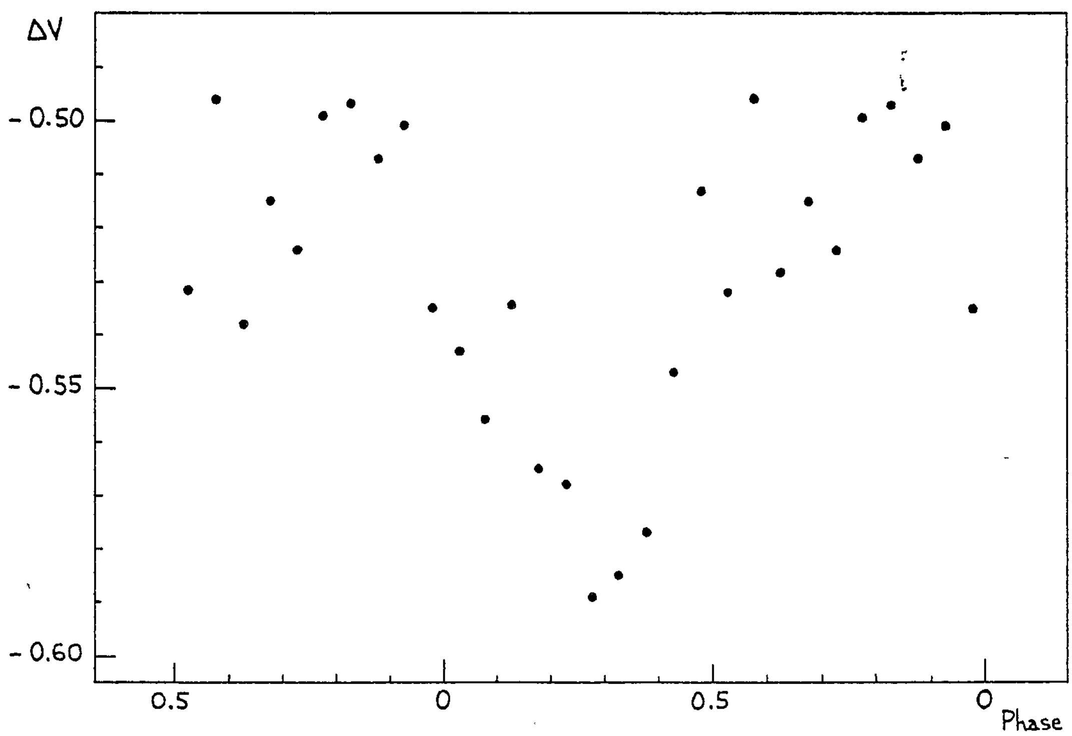

Fig. 4. BROGLIA's V mean curve for secondary period P_1 (ephemeris 1'). Dots are means on 0.05 period from 860 V measurements in 1958-59.

Tables 5 and 6 give the numerical values used for the plotting of Figs. 3 and 4.

Phase ϕ	Number n	mean Mag. $\bar{m}$	Phase ϕ	Number n	mean Mag. $\bar{m}$
0.025	73	12.105	0.525	78	12.006
0.075	81	12.076	0.575	71	12.026
0.125	72	12.082	0.625	73	12.025
0.175	99	12.047	0.675	64	12.029
0.225	82	12.022	0.725	70	12.013
0.275	90	12.020	0.775	83	12.035
0.325	86	12.010	0.825	82	12.042
0.375	85	12.041	0.875	88	12.053
0.425	84	12.021	0.925	84	12.056
0.475	75	12.034	0.975	86	12.093

Table 5. Mean points for Figure 3 (from the visual estimates): Phase ϕ refers to ephemeris 1′, n is the estimates number and $\bar{m}$ is the mean magnitude for phase ϕ.

Phase ϕ	Number n	mean Mag. $\overline{\Delta V}$	Phase ϕ	Number n	mean Mag. $\overline{\Delta V}$
0.025	44	-0.543	0.525	41	-0.532
0.075	39	-0.556	0.575	46	-0.496
0.125	34	-0.534	0.625	39	-0.538
0.175	42	-0.565	0.675	40	-0.515
0.225	34	-0.568	0.725	49	-0.524
0.275	39	-0.589	0.775	42	-0.499
0.325	43	-0.585	0.825	51	-0.497
0.375	39	-0.577	0.875	48	-0.507
0.425	43	-0.547	0.925	49	-0.501
0.475	48	-0.513	0.975	50	-0.535

Table 6. Mean points for Figure 4 (from BROGLIA's V measures): Phase ϕ refers to ephemeris 1′, n is the measures number and $\overline{\Delta V}$ is the mean magnitude for phase ϕ.

5. CONCLUSION

This study emphasizes the interest of visual estimates performed according to the GEOS philosophy, that is to say managing to obtain large concentrations of measures on a few selected stars.

The visual observations of BP Pegasi in 1976-77 show a negative O-C with reference to BROGLIA's ephemeris (1), and allow one to propose a slightly more accurate new ephemeris for the fundamental period.

It has also been possible to evidence visually the Blazhko effect in BP Pegasi, obtaining a good mean curve on the secondary period of 0.084 510 day, though this oscillation has an amplitude as low as 0.1 magnitude.

This result is especially significant of the possibilities of visual observations, as a suggestion effect can be ruled out here since the secondary oscillation is not a phenomenon observed directly and the observers at S^T ROME did not know at all of the Blazhko effect of BP Pegasi.

Moreover it brings a good confirmation of BROGLIA's determination of the beat period.

A. FIGER

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