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44 TIMES OF MINIMUM AND FIRST EPHEMERIS FOR THE EW STAR FZ ORIONIS

ABSTRACT. FZ Orionis is an under-studied variable star. The 1.597 ? day period, given in the GCVS(69), is erroneous. This conclusion is supported by the present analysis of 1229 visual estimates made by the author in 111 nights from 1976 to 1982.

44 minima (standard deviation 13.5 mn) have been observed (see Tab. 2), leading to the following ephemeris :

(1) Min I = Hel. J.D. 24 44 024. 4583 ± 14 + 0. 39 998 66 E ± 18

(95 % level of confidence for the error bands)

FZ Orionis is an EW-type star. Owing to the great number of observations, it has been possible to discriminate the primary minima from the secondary ones, despite their rather close amplitudes.
The range of the v-variation is a rough estimation. The probable v-magnitudes are : Max 10.7 , Min I 11.3 , Min II 11.25 .

RESUME. FZ Orionis est une étoile variable sous-étudiée. La période de 1,597 ? jour, donnée dans le GCVS(69) est erronée, ainsi qu'ont permis de le montrer les 1229 estimations visuelles effectuées par l'auteur au cours de 111 nuits de 1976 à 1982.

44 minimums (d'écart-type 13,5 mn) ont été observés (voir Tableau 2). L'éphéméride obtenue est :

(1) Min I = J.J. hél. 24 44 024. 4583 ± 14 + 0. 39 998 66 E ± 18

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

FZ Orionis est une EW. Grâce au grand nombre d'observations, il a été possible de discriminer les minimums primaires des secondaires, malgré leur faible différence d'amplitude.
L'amplitude visuelle de la variation reste déterminée de façon très imprécise. Les magnitudes probables sont : Maximum 10,7 v , Min I 11,3 v , Min II 11,25 v .

RIASSUNTO. FZ Orionis è una stella variabile poco studiata. Il periodo di 1,597 ? giorni attribuitole nel GCVS(69) appare erroneo, come permettono di dimostrare le 1229 stime visuali effettuate dall'autore nel corso di 111 notti dal 1976 al 1982. Sono stati osservati (vedi tabella 2) 44 minimi (con scarto tipo di 13,5 minuti). L'effemeride dedotta è :

(1) Min I = G.G.(hel.) 24 44 024. 4583 ± 14 + 0. 39 998 66 E ± 18

(le bande d'errore sono espresse con affidabilità del 95 %)

FZ Ori è una variabile del tipo EW. Il gran numero di osservazioni effettuate ha reso possibile discriminare i due minimi, primario e secondario, nonostante la loro piccola differenza d'ampiezza. L'ampiezza visuale della variazione risulta determinata in maniera assai approssimata : le magnitudini probabili sono comunque : Massimo = 10,7 v , Min I = 11,3 v , Min II = 11,25 v .

RESUMEN. FZ Orionis es una estrella variable poco estudiada. El periodo de 1,597 ? días dado en el GCVS(69) es erróneo, tal y como lo demuestran las 1229 estimaciones visuales efectuadas por el autor durante 111 noches desde 1976 hasta 1982.

44 mínimos (de desviación-tipo 13,5 mn) han sido observados (ver Tabla 2). La efeméride obtenida es esta :

(1) Min I = D.J.Hel. 24 44 024. 4583 ± 14 + 0. 39 998 66 E ± 18

(las bandas de error han sido expresadas con un nivel de confianza del 95 %)

FZ Orionis es una EW. Gracias al gran número de observaciones, ha sido posible separar los mínimos primarios de los secundarios, a pesar de su pequeña diferencia de amplitud.
La amplitud visual de la variación ha quedado determinada de forma muy imprecisa. Las magnitudes probables son : máximo 10,7 v , mín I 11,3 v , mín II 11,25 v .

1. INTRODUCTION

FZ Orionis, with coordinates 1950.0 : α 05 h 38 m 45 s , δ + 02° 35'. 0 , was proved to be a photographic variable by C. HOFFMEISTER in 1934 .

Very few papers have been devoted to FZ Orionis, according to "A Finding List" (F.B. WOOD et al.,1980).
A. SOLOVIEV (1945) concluded that the star was a W UMa with a 0.9 magnitude photographic amplitude, whereas R. KIPPENHAHN (1953), giving 3 times of minimum, referred to the 1.597 day period of this β Lyrae-type star.

The information available has been summarized in the G.C.V.S. (B.V. KUKARKIN et al.,1969) as follows : " Type EW ? , photographic range 10.0 to 11.0 , period 1.597 ? day , spectrum G0 , hel. minimum = J.D. 24 31 138. 174 (that is, in February 1944) " .

In 1976, FZ Orionis was added to the GEOS observing programme, among other under-studied variable stars.

2. OBSERVATIONS

From 1976 to 1982, I made 1229 visual estimates in 111 nights at Paris, using an 8-inch and a 10-inch reflector with respective magnifications 48x and 57x . (see Table 1)

OBSERVING SEASON	NUMBER OF NIGHTS	TELESCOPES	NUMBER OF ESTIMATES
DEC 76 to MAR 77	16	8"	199
AUG 77 APR 78	25	8"	281
OCT 78 APR 79	19	8 and 10"	127
SEP 79 MAR 80	19	8 and 10"	198
OCT 80 MAR 81	22	10"	307
NOV 81 MAR 82	10	10"	117
	111		1229

Table 1. Time coverage of the observations

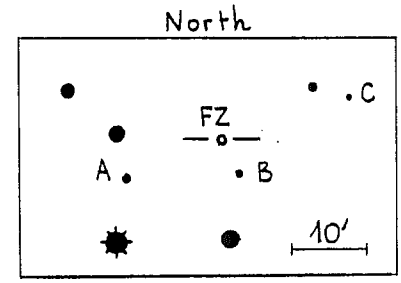

Figure 1. FZ Ori and its comparison stars

The estimates were made according to the Argelander method using the three comparison stars shown in Figure 1, taken from GEOS Chart C 74 . As their accurate magnitudes are unknown, I estimated the brightness of A, B and C using a scale available for RV Tau. My rough estimation, made on 1982 January 16 , gave : A = 10.3 B = 10.9 C = 11.4 .

3. DISCUSSION

3.1 Eclipsing binary nature

The half-a-magnitude variation of FZ Ori is nearly sinusoïdal with an apparent period slightly less than 5 hours. As an example, observations made on two different nights (1981 January 25-26 and 30-31) are shown in Figure 2.

During a whole season, minima and maxima occur at the same time of day. There are 5 cycles per day, that is a 4.8 hour apparent period (0.20 day). It is not too difficult, for instance by considering the yearly mean curves, to discriminate two different types of minimum (Min I and II), despite their rather small difference in depth.

So, FZ Orionis turns out to be an eclipsing variable with a 0.40 - day period .

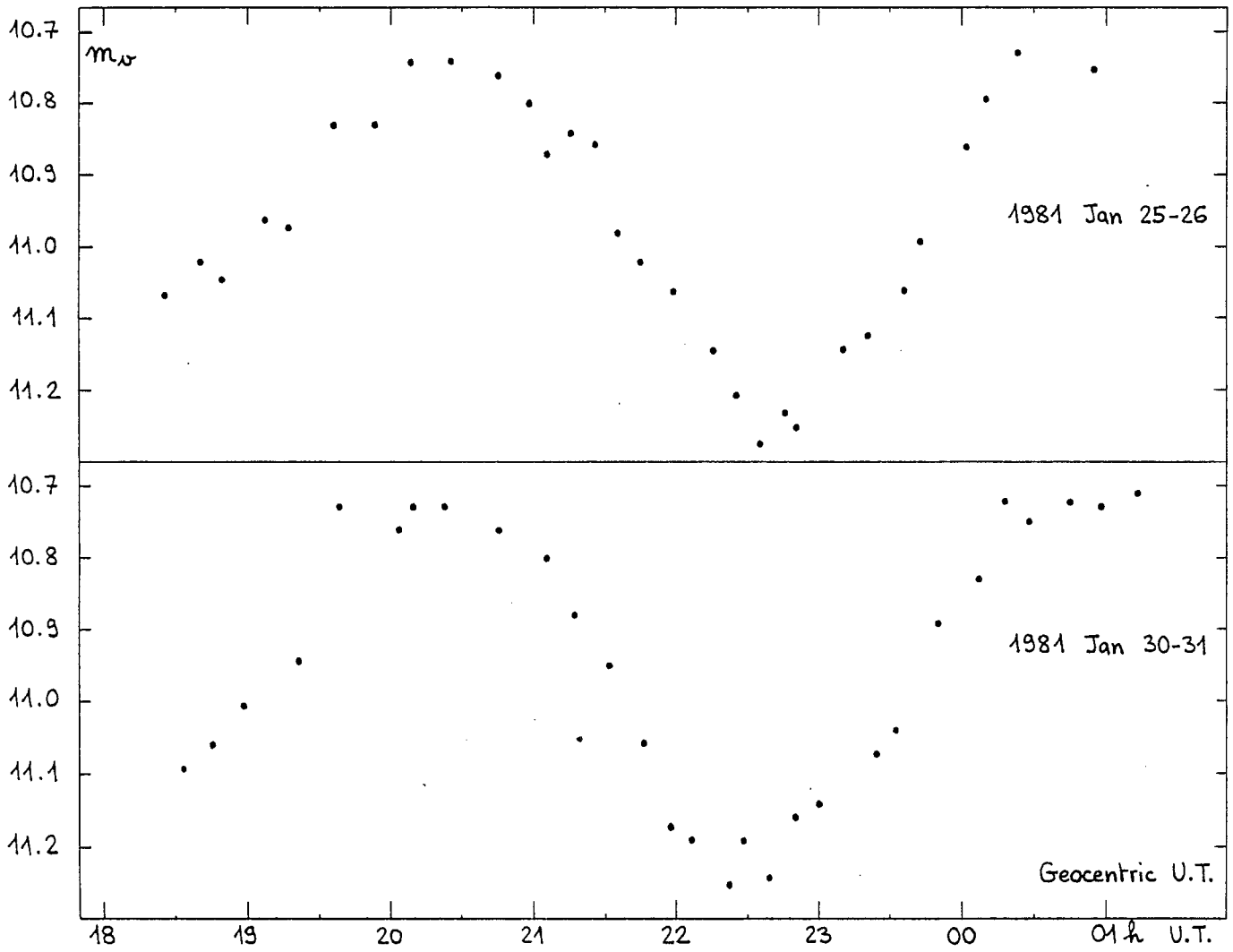

Figure 2. FZ Ori : visual observations by A. FIGER on 1981 January 25-26 and 30-31 .

3.2 List of the observed minima

The 44 observed minima have been determined using the tracing paper method (see Table 2).

3.3 First ephemeris for FZ Ori

It is possible to derive rough ephemerides from each set of minima obtained during each of the 6 observing seasons. All the values found for the period agree well together within the error bands.
Due to the higher number of minima and longer time coverage, 1977-78 and 1980-81 provide the most accurate values, respectively :
0.39 999 day ± 0.00 002 day and 0.39 999 day ± 0.00 003 day .

This result is accurate enough to allow us to link the observations of one observing season to another in one manner only : in every case, the number of elapsed periods between the epochs used as a basis for the 6 ephemerides is doubtlessly single.

Finally, taking in account the 44 minima, ephemeris (1) is computed :

(1) Minimum I = Hel.J.D. 24 44 024.4583 ± 14 + 0.39 998 66 ± 18 E

(95 % confidence interval for the error bands)

Table 2 lists the O-C's of the minima according to ephemeris (1).

Their standard deviation is : s(O-C) = 0.0094 day , that is 13.5 mn , a fairly good result, considering the observing conditions in Paris.

GEOCENTRIC TIME OF MINIMUM		HELIOCENTRIC TIME OF MIN.	REFERENCE : EPHEMERIS (1)		GEOCENTRIC TIME OF MINIMUM		HELIOCENTRIC TIME OF MIN.	REFERENCE : EPHEMERIS (1)	
DATE	U.T.	J.J. 2400 000 +	E	O-C	DATE	U.T.	J.J. 2400 000 +	E	O-C
77 JAN 23	23h35	43167.487	-2142.5	-0.000	79 DEC 28	22h28	44236.441	+ 530.	-0.010
27	18 55	171.292	-2133.	+ .005	80 JAN 02	22 22	241.437	+ 542.5	- .014
27	23 41	171.491	-2132.5	+ .004	28	22 39.5	267.448	+ 607.5	- .002
29	23 03.5	173.465	-2127.5	- .022	FEB 10	22 41	280.448	+ 640.	- .002
30	23 19	174.475	-2125.	- .012	18	22 21	288.433	+ 660.	- .016
31	18 40	175.281	-2123.	- .006					
FEB 28	18 55	203.290	-2053.	+ .004	80 OCT 10	03h21.5	44522.642	+1245.5	+ .000
					DEC 07	22 34.5	581.446	+1392.5	+ .006
77 SEP 11	04h20	43397.680	-1567.	+ .001	25	22 38	599.448	+1437.5	+ .009
DEC 03	23 29	481.484	-1357.5	+ .007	81 JAN 11	22 17	616.433	+1480.	- .005
17	23 51	495.499	-1322.5	+ .023	15	22 03	620.423	+1490.	- .015
18	23 34	496.487	-1320.	+ .011	25	22 38.5	630.447	+1515.	+ .009
78 JAN 03	23 21	512.478	-1280.	+ .002	28	22 41.5	633.449	+1522.5	+ .011
26	18 26	535.272	-1223.	- .003	30	22 33	635.443	+1527.5	+ .005
26	23 14.5	535.472	-1222.5	- .003	31	22 22.5	636.436	+1530.	- .002
28	23 28	537.482	-1217.5	+ .007	FEB 01	22 16.5	637.432	+1532.5	- .006
FEB 28	18 48	568.285	-1140.5	+ .011	14	22 39	650.446	+1565.	+ .009
MAR 05	18 50	573.286	-1128.	+ .013					
06	18 42	574.280	-1125.5	+ .007	81 DEC 19	22h23	44958.438	+2335.	+ .011
07	18 38	575.277	-1123.	+ .004	82 JAN 12	22 08	982.427	+2395.	+ .001
					16	22 01	986.422	+2405.	- .004
78 NOV 20	22h51	43833.457	- 477.5	- .008	FEB 21	22 12	45022.427	+2495.	+ .002
79 JAN 06	22 40	880.449	- 360.	- .014	MAR 13	22 08	042.424	+2545.	- .000
13	18 05	887.258	- 343.	- .005					
13	22 41	887.450	- 342.5	- .013					

Table 2. FZ Ori : List of the 44 observed minima.

Owing to the length of the interval of time elapsed, it has not been possible to link the present observations to the earlier minimum, somewhat doubtful, published in the GCVS, nor to the 3 earlier minima by KIPPENHAHN.
However, these 3 minima (at J.D. 24 26 734.358 , 24 27 098.370 and 24 27 398.538 are consistent with each other if our period is used : assuming 910 cycles between the two earlier minima and 750.5 between the last two, the linear regression yields a value of 0.39 999 day for the period. ± 5

3.4 FZ Ori mean light-curve

All the measures, except those made during 1978-79, have been used to plot the mean light-curve shown in Figure 3. In fact, the 1978-79 estimates were inaccurate due to an error in the choice of the comparison stars.

So the mean curve is obtained from 1102 estimates averaged on intervals of 0.02 period. The 50 mean points are listed in Table 3.

The amplitude of variation is close to 0.4 mag according to Figure 3. Nevertheless this value is clearly underestimated. It is well-known that visual mean curves often underestimate the amplitudes, although the reason for this still requires a decisive statement.
Considering the best individual light-curves, I think a 0.6 mag amplitude to be more suitable for Min I. The corresponding amplitude is 0.55 mag for Min II.
So the range could be 10.7 - 11.3 v , with Min II at 11.25 v .

φ	n	$\bar{m}$	φ	n	$\bar{m}$	φ	n	$\bar{m}$
0.00	36	11.199	0.34	18	10.882	0.68	24	10.840
0.02	27	11.192	0.36	23	10.882	0.70	25	10.842
0.04	32	11.169	0.38	19	10.928	0.72	13	10.837
0.06	23	11.117	0.40	25	11.012	0.74	20	10.814
0.08	30	11.074	0.42	20	11.057	0.76	19	10.806
0.10	26	11.023	0.44	20	11.108	0.78	16	10.809
0.12	35	10.989	0.46	24	11.113	0.80	11	10.775
0.14	27	10.945	0.48	22	11.155	0.82	14	10.862
0.16	21	10.869	0.50	23	11.164	0.84	20	10.860
0.18	22	10.848	0.52	22	11.181	0.86	20	10.957
0.20	25	10.814	0.54	26	11.115	0.88	18	10.933
0.22	23	10.829	0.56	25	11.095	0.90	16	11.006
0.24	16	10.785	0.58	18	11.063	0.92	21	11.069
0.26	21	10.792	0.60	25	11.021	0.94	22	11.153
0.28	16	10.766	0.62	23	10.972	0.96	21	11.183
0.30	19	10.819	0.64	28	10.945	0.98	14	11.193
0.32	22	10.828	0.66	26	10.927			

Table 3. 1102 estimates of FZ Ori : Mean magnitudes ($\bar{m}$) according to phase (φ). n is the number of estimates in each mean. The phase refers to ephemeris (1).

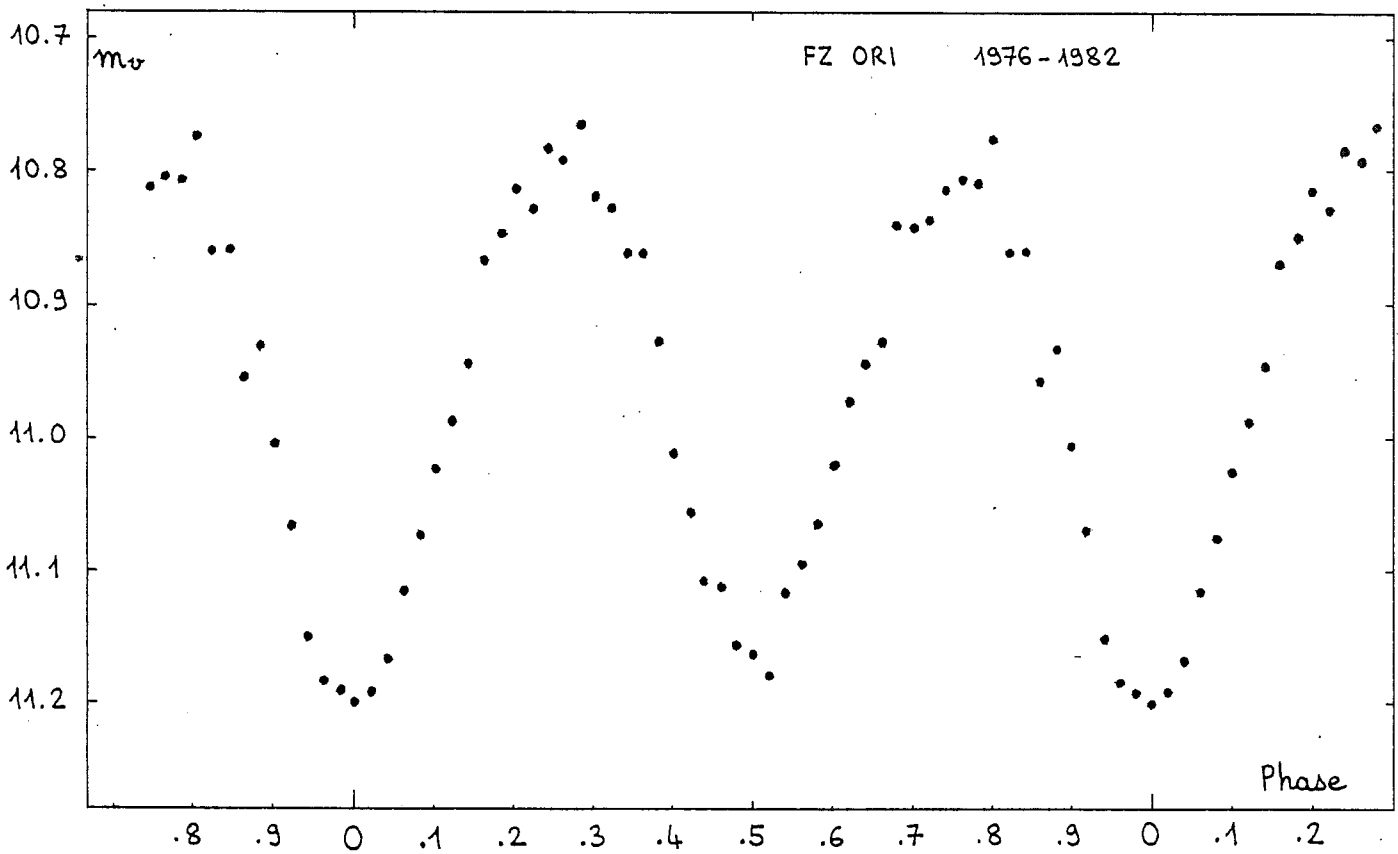

Figure 3. FZ Ori : Mean light-curve, according to ephemeris (1).

In that case, the scatter of the mean points around a smooth light-curve is close to 0.025 mag (standard deviation). With about 20 estimates per mean point, this is consistent with a 0.1 mag accuracy of the individual estimates.

4. CONCLUSION

The period value given in the GCVS is erroneous. The true value, roughly four times shorter, is typical of a G0 V EW star.

An accurate ephemeris is now available for FZ Orionis. Forthcoming visual estimates will allow to check the period constancy of this W UMa type eclipsing binary.

On the other hand, photoelectric measures are required to establish the true amplitude and to compute an accurate model for the FZ Ori binary system.

A. FIGER

BIBLIOGRAPHY

FIGER A., 1981, GEOS NC 313; Etoiles Eclipsantes. Bulletin d'Information nº 19. "Annonce d'une prochaine GEOS Circ. consacrée à FZ Orionis".

HOFFMEISTER C., 1934, AN 253,195. " 132 neue Veränderliche ".

KIPPENHAHN R., 1953, AN 281,153. "Mitteilungen über 18 verdächtige und veränderliche Sterne ".

KUKARKIN B.V. et al., General Catalogue of Variable Stars, Moscow 1969, Third Edition.

SOLOVIEV A., 1945, Astr. Circ. 41, 8. "Notes on the unstudied variable stars".(in Russian)

WOOD F.B. et al., A Finding List for observers of interacting binary stars, Philadelphia 1980, Fifth Edition.