GEOS
SR 13

GEOS CIRCULAR ON RED VARIABLE STARS

1995 February 27

GEOS

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U Del

SLOW VARIATIONS WITH TWO APPARENT PERIODS

Summary : The red variable U Del has been extensively observed by GEOS observers from 1983 to 1992. An analysis of their observations supports the existence of a period of 1120 d. By subtracting the signal relative to this period, a second period of about 660 d. can be evidenced.

Résumé : La variable rouge U Del a été beaucoup observée par les membres du GEOS de 1983 à 1992. L'analyse de ces observations montre l'existence d'une période de 1120 jours. En soustrayant le signal relatif à cette période, on peut découvrir une seconde période d'environ 660 jours.

Resumen : La variable roja U Del ha sido muy observada por los miembros del GEOS entre 1983 y 1992. El analisis de estas observaciones muestra la existencia de un periodo de 1120 dias. Substrayendo la señal relativa a este periodo, se descubre un segundo periodo de alrededor de 660 dias.

Sommario : La variabile rossa U Del è stata oggetto di numerose osservazioni da parte dei membri GEOS dal 1983 al 1992. L'analisi di tali osservazioni mostra l'sistenza di un periodo di 1120 giorni. Sottraendo il segnale relativo a tale periodicità è possibile scoprire un periodo secondario di circa 660 giorni.

1. Introduction

The variable star U Del has always been widely observed by amateurs and more particularly by GEOS observers during the last decade. The GCVS (1985) reports an SRb type, with a range 7.6 to 8.9 (p), an M5 II-III spectrum and a period of 110 d. Ralincourt (1980) surmised a more probable period of 160 d. More recently, Schult, Sonneberg and Lehman (1990) reported periods of 1160 and 710 d.

2. Observations

More than 3300 brightness estimates were made from 1983 to 1992 by 17 GEOS observers. The observations were made by the Argelander method, using the comparison stars given in Table 1.

COMPARISON	N° HD	COORDINATES	Mv	SP
F	200044	21h00m,5 +19°19',8	5,65	M2III
G	197249	20h42m,0 17°31',3	6,22	G8III
H	196345	20h36m,4 16°48',9	6,6	K2III
K	197940	20h46m,4 16°54',2	7,1	K2III
L	198109	20h47m,6 16°14',3	7,5	F8V

Table 1 : comparison stars (catalogue SKY 2000)

The data relative to each observer are given in Table 2. Since VBR used a fractional method while CLM's estimates were made with comparison stars G ans K only, I have assigned the magnitudes given in the Sky 2000 catalogue to the comparison stars used by both observers. Similarly, CBO obtained two series, each with the same number of estimates, based on sequences H-K-L and H-L respectively. For that reason, CBO's estimates appear as two separate sequences in Table 2.

Computing each observer's systematic error and standard deviation has been done using the star's light curve between 1989 and 1991 as a reference, because the observations are evenly distributed and their density strongest during that interval. It is reasonable to suppose that each observer's systematic error remains approximately the same as long as he observes the same star with the same method.

OBSERVATEUR	SIGLE	Nb	SEQUENCE PERSONNELLE					DEGRE	Δm_2	σ_2
			F	G	H	K	L			
ACERBI F.	ACR	128		6,23	6,61	7,06	7,53	0,07	0,10	0,10
BARANI C.	BAR	171		6,27		6,98	7,57	0,11	0,05	0,10
BARUFFETTI P.	BFF	102		6,22	6,61	7,08	7,51	0,08	0,01	0,08
CANOLA B.	CNO	102		6,20	6,63	7,09		0,11	-0,07	0,07
CHECCUCCI M.	CHC	411	5,72	6,13	6,61	7,09	7,52	0,12	-0,15	0,08
COLOMBA A.	CLM	105							-0,11	0,15
COLOMBO T.	CBO	218		6,18	6,67 6,76	7,07	7,49 7,43	0,09	0,15	0,19
DUMONT M.	DMT	437	5,68	6,18	6,59	7,12		0,08	0,02	0,12
EYRAUD J.	EYR	432		6,23	6,61	7,05	7,53	0,08	-0,02	0,09
FRANGEUL M.	FRL	137		6,19	6,64	7,09	7,48	0,06	0,07	0,16
GOBET F.	GBF	277		6,19	6,65	7,10	7,48	0,11	0,10	0,14
GUIMEZANES Y.	GMZ	39	5,65	6,23	6,59	7,06	7,52	0,09	-0,04	0,09
IELO A.	LIE	307		6,18	6,61	7,05	7,55	0,06	-0,04	0,12
MAMMOLITI S.	MAM	231		6,20	6,64	7,07	7,51	0,08	0,19	0,30
RALINCOURT P.	RAL	98		6,22	6,65	7,02	7,54	0,08	0,01	0,09
VANDENBROERE J.	VBR	40							-0,34	0,04
VILLI M.	VLL	78		6,21	6,62	7,09		0,13	-0,02	0,13

Table 2 : Comparison sequences, systematic errors and standard deviations after the second iteration

3. Discussion

The mean light curve was plotted by an iterative process weighting each observer's estimates in function of his personal standard deviation. Fig. 1 shows the trend of the curve from 1983 to 1992. The search for periodicities was made by the PDM method.

A first frequency f_0 is visible at $8.9.10^{-4}$ $d.^{-1}$, which corresponds to a period of a little over 1120 days. Graph 1 in fig. 2 shows the periodogram and frequency f_0.

In order to evidence a second period, a signal fitted on the first period was subtracted. The new periodogram then shows a frequency f_1 at $15.1.10^{-4}$ d^{-1}, i.e. a period of 660 days (fig. 2, graph 2). It must be noted that the value of this second period is nearly half the value of the first and that the PDM method does not introduce any pseudo-period at frequency $2f_0$. However, the new frequency f_1 is not very conspicuous on the periodogram.

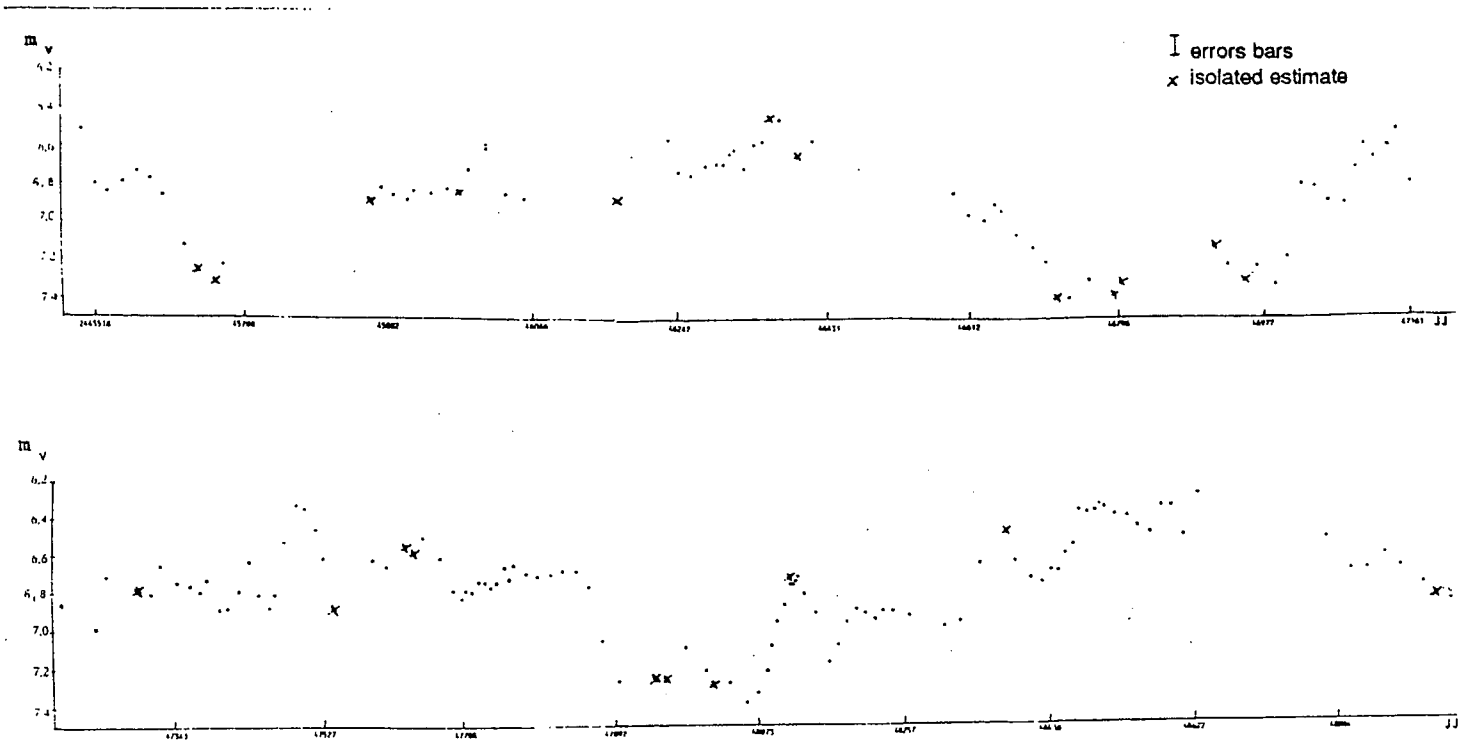

fig. 1 : Mean light curve of U Del from 1983 to 1992.

A computation of the 0-Cs (Table 3) relative to the second period, using the light curve after removing the signal fitted on the first period, gives :

P = 660 d. ∓ 12 d. (fig. 3)

at the 95 % level. The period reported by Schult et al. is well outside the margin.

The point marked "?" is an average of two estimates. The spurious variations that can be noticed for the last three maxima (based on the second period) show that relatively rapid and probably aperiodic variations are superimposed over the two basic periods that are more or less regular.

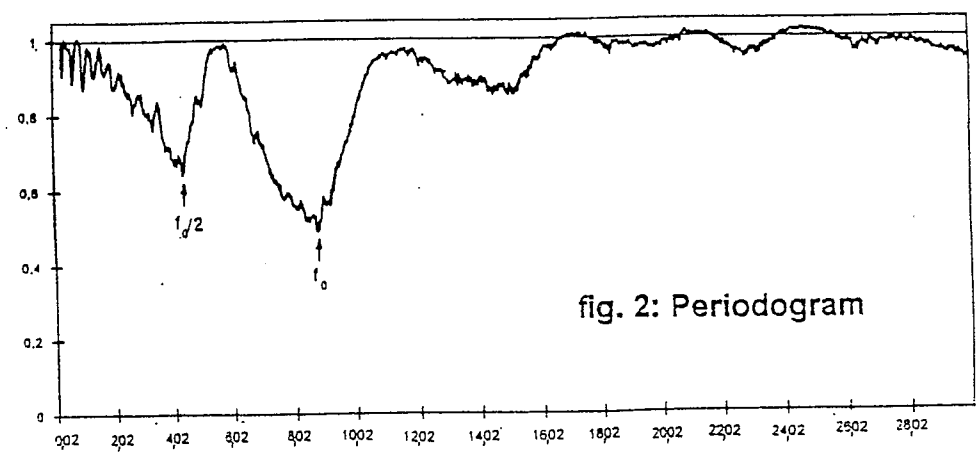

fig. 2: Periodogram

- Graph 1 : Processing jof the observations by the PDM method evidencing the presence of f_1 ; the observations are as they appear on figure 1.

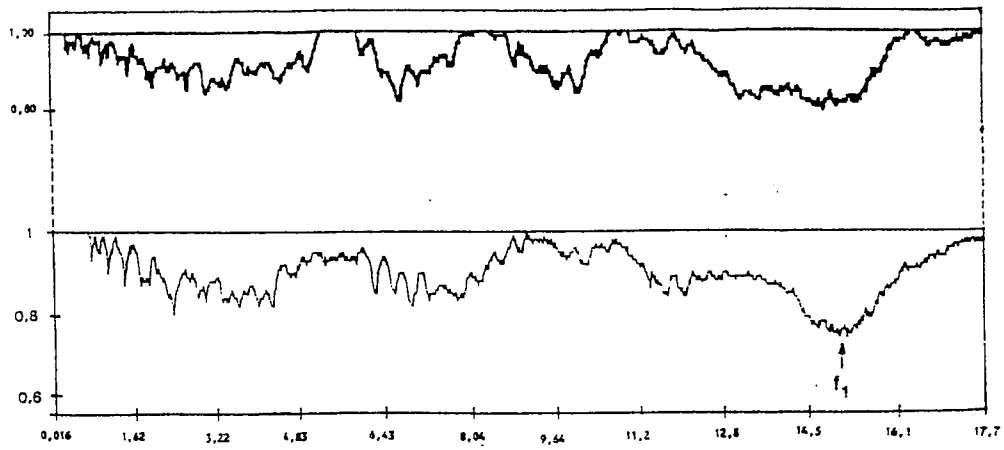

fig. 2 : Periodograms

The abscissae represent frequencies in units of 10^{-4} $d.^{-1}$. The PDM structure (Nb, Nc) is equal to (5,2). On graph 1, the number of frequencies calculated is 1500, the step is 2.10^{-6} d^{-1}. On graph 2, the corresponding values are 1100 and $1.6.10^{-6}$ d^{-1} respectively.

- Graph 2 :

(upper) : Application of the same process after removing the first signal of frequency f_0.

(lower) : Same treatment, applying a shifting average on two points.

E	O	C_{660}	C_{710}	$(O-C)_{660}$	$(O-C)_{710}$
-2.0	-1301	-1320	-1420	19	119
-1.5	-1002	-990	-1065	-12	63
-1.0	-668	-660	-710	-8	42
-0.5	-307	-330	-355	23	48
0.5	357	330	355	27	2
1.0	664	660	710	4	-46
2.0	1328	1320	1420	8	-92

Table 3 : Values observed for the O - Cs

Conclusions

The second periodogram shows that the second period is not very regular and that it would be quite unwise to look for other periodicities with that type of method.

The slow variations over intervals of 1120 d. and 660 d. seem to be well established and quite close to the results obtained by the team at the Iena Institute.

The light curve of U Del, which is situated on the Ascending Giant Branch of the HR diagram is characteristic of a red semi-regular. U Del has a P_0/P_1 ratio close to 2. Referring to the theoretical study by Fox and Wood (1982) on the periods of radial pulsations in long-period red variables (see their Table 2), P_1 ($\sim$ 600-700 d.) is the pulsation period corresponding the first harmonic and P_0 ($\sim$1100-1200 d.) is the period corresponding to the fundamental mode. In short, the simultaneous presence in the star of the two pulsations modes is reflected in the light curve.

The results of Fox and Wood predict a mass of about 1.5 $M_\odot$ and a luminosity ratio $L/L_\odot$ close tot 25000 for a star showing such periods.

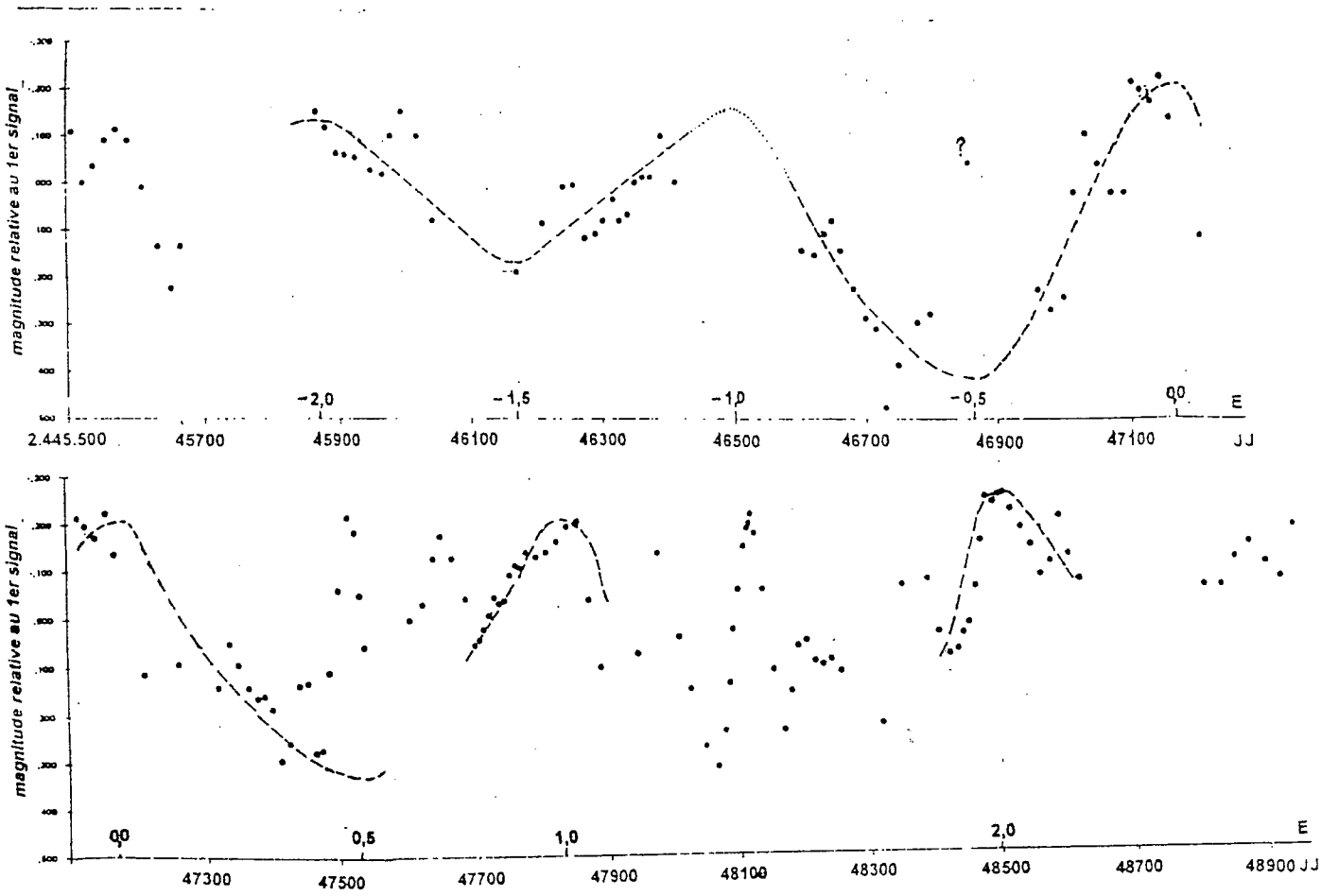

Fig. 3 : Light curve showing the second period of 660 days. First, a moving average on two points of the initial curve was applied and the first signal of frequency f_0 was then subtracted. An application of the PDM process to the value of the points shown on figure 2 gave the lower periodogram in Graph 2.

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