GEOS EB 11

GEOS CIRCULAR ON ECLIPSING BINARIES

1983 November 18

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LO ANDROMEDAE : A NEW CLOSE ECLIPSING BINARY SYSTEM

ABSTRACT - Discovered in 1963 by R. WEBER, LO AND was first regarded as a pulsating star. A first ephemeris (I) was computed using the visual observations of A. GAUTSCHY made in 1979. Photoelectric measures made by R.DIETHELM confirmed the shortness of the period. Since 1981, about 4300 estimates from the GEOS observers have led to the conclusion that the star is an EW-type eclipsing binary. That conclusion agrees well with the mean B-V of LO AND.

From 104 minima, the following elements were calculated :

Min I = Hel. J.D. 2445075.6353 + 0.3804326 E (2)
± 8 ± 28

(95% confidence interval for the error bands)

It has not been possible to discriminate with certainty , between primary and secondary minimum. LO AND varies from 11.20 to 11.75 v with a secondary minimum around 11.70 v. Further observations are needed.

RESUME - Découverte en 1963 par R.WEBER, LO AND a d'abord été considérée comme une étoile pulsante. Les observations visuelles entreprises par A.GAUTSCHY en 1979, ont permis de calculer une éphéméride (I). Les mesures photoélectriques de R.DIETHELM confirment la période rapide. Les quelques 4300 estimations effectuées par le GEOS entre 1981 et 1983, permettent de conclure que l'étoile est une binaire à éclipses de type EW. Le B-V moyen de l'étoile (+0.62) renforce cette conclusion. Calculée à partir de 104 minima, l'éphéméride est la suivante :

Min I = J.J. hel. 2445075.6353 + 0.3804326 E (2)
± 8 ± 28

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

Il n'a pas été possible de différencier, avec certitude ,les minima primaires et secondaires. LO AND varie de 11.20 à 11.75 v avec un minimum secondaire à 11.70 v environ. D'autres observations sont nécessaires.

RIASSUNTO - Scoperta nel 1963 da R.WEBER, LO AND fù inizialmente ritenuta una variabile pulsante. Osservazioni visuali effetuate nel 1979 da A.GAUTSCHY hanno permesso di calcolarne una effemeride (I). Misure fotoelettriche di R.DIETHELM confermano l'esistenza di un periodo rapido. Le circa 4300 stime effetuate del GEOS fra il 1981 e il 1983 permettono di concludere che la stella è una binaria a eclisse del tipo EW. Questa conclusione è rafforzata dal B-V medio della stella (+0.62). L'effemeride, calcolata sulla base di 104 minimi è la seguente:

Min I = G.G. el. 2445075.6353 + 0.3804326 E (2)
± 8 ± 28

(le bande d'errore sono riferite ad un livello di confidenza del 95%)

Non è stato possibile differenziare, con sicurezza ,i minimi primari dai secondari. LO AND varia dalla 11.20 alla 11.75 v con un minimo secondario a circa 11.70 v. Si rendono perciò necessarie ulteriori osservazioni.

RESUMEN - Descubierta en 1963 por R.WEBER, LO AND fue en principio considerada como una estrella pulsante. Las observaciones visuales emprendidas por A.GAUTSCHY en 1979 han permitido calcular una efeméride (I). Las medidas fotoeléctricas de R.DIETHELM confirman el periodo rápido. Las 4300 estimaciones efectuadas por el GEOS entre 1981 y 1983 permiten concluir que la estrella es una binaria a eclipses de tipo EW. El B-V medio de la estrella (+0.62) refuerza esta conclusión. La efeméride, calculada a partir de 104 mínimos, es la siguiente:

Min I = D.J.hel. 2445075.6353 + 0.3804326 E (2)
± 8 ± 28

(bandas de error al nivel de confianza del 95%)

No ha sido posible diferenciar con certeza los mínimos primarios de los secundarios. LO AND varia de 11.20 a 11.75 v con un mínimo secundario de 11.70 v aproximadamente. Nuevas observaciones son necesarias.

I. Introduction

Photographically discovered in I963, this star is regarded by R.WEBER as a cepheid ranging from II.4 to I2.3 p . LO AND was designated, in previous list and catalogues ,as follows: WR I36, CSV 8853, NSV I4569.

During the summer of I979, A.GAUTSCHY visually observed I5 times of maximum light, from which he derived the following elements :

J.D. max hel = 2444065.462 + 0.I90429 E (I)

Simultaneously, photoelectric observations were performed during two nights by R.DIETHELM with the Gornergrat I-metre telescope (CH). Short period variations were confirmed; a 0.6 V magnitude amplitude and a mean value of + 0.62 for B-V, were deduced.

2. Observations

More than 4300 estimates from I6 GEOS observers have been performed since the summer of I98I. About 65% of the estimates were made during two summer camps: held at Casinos (Spain) in July-August I98I and at Bédarieux (France) in July I982. The variable and the comparison stars used are given in Figure I. Three of them were used by R.WEBER and two are also present on the AL AND chart from the AAVSO (see Table I).

Compar. stars	v magn. GEOS	V magn. AAVSO	p magn. R.WEBER
A	I0.8	I0.6	II.5
B	II.2	I0.8	II.2
C	II.7	-	II.9
D	I2.I	-	-

Table I: Comparison stars magnitude from different sources

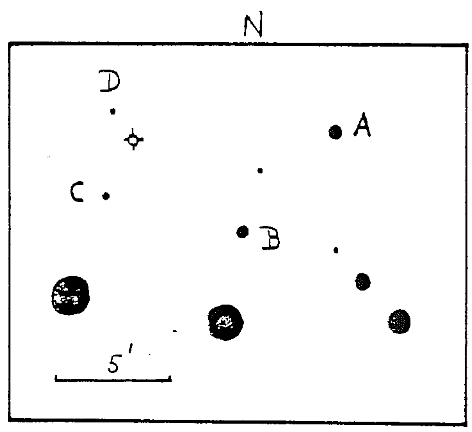

Figure I: LO AND and its comparison stars

$\alpha = 23^h\ 24^m\ 42^s$, $\delta = +45^\circ\ 17'.5$ (I950)

3. Discussion

3.I LO AND is not a pulsating star

Very soon, short period variations appeared to the GEOS observers, as well as the trend of the curve with minima sharper than maxima. These facts are in favour of an EW-type eclipsing binary rather than a pulsating star. That conclusion is strengthened by the B-V mean value (+0.62), obtained by R.DIETHELM, which is typical of a G0-G2 V star. The period (I) announced by A.GAUTSCHY would be, in fact ,the half period.

3.2 Lists of minima

A total of I02 well-observed times of minima have been collected by the GEOS observers. These visual minima were determined by the tracing paper method. Table 2 presents, for each observer ,the number of minima observed during each season and the total number of estimates. Table 3 gives the list of the I04 minima, including two photoelectric minima observed by R.DIETHELM in I979 ,with the O-C's according to ephemeris (2).

Observers	Place	Ab.	Number of Minima					Total numb. est.
			Casin. 8I	8I-82	Bédar. 82	82-83	Tot.	
M. Benucci	I Firenze	BEN			5		5	I62
R. Boninsegna	B Dourbes	BNN		I6	5	7	28	753
J. Busquets	E Valencia	BSQ	5		4		9	500
G. Dumarchi	F Savigny	DCH						20
J. Fabregat	E Valencia	FBG	5		3		8	460
S. Ferrand	F Bougival	FND			3		3	9I
A. Figer	F Paris	FGR	6		5	4	I5	578
P. Graulus	B Braine	GUS	3	2			5	234
P. Guiraudou	F Montpellier	GUI	3		2		5	322
JF.Leborgne	F Bagnères	FLB						I5
R. Leyman	B Leval	LEY		I			I	I6
P. Louis	B Namur	LSP				3	3	63
P. Matagne	B Bruxelles	MAT	6				6	448
E. Nezry	F Toulouse	NZY	3				3	307
P. Ralincourt	F Nantes	RAL	6		4		IO	379
P. Wils	B Niel	WLS				I	I	4I
	TOTAL		37	I9	3I	I5	I02	4389

Table 2: List of the observers, number of minima for each season and total number of estimates.

Next page - Table 3: List of the 104 minima of LO Andromedae with O-C's according to ephemeris (2). "n" is the number of estimates used for the determination and "E" the number of cycles.

hel.JD 2440000+	n	E	Obs	O-C	hel.JD 2440000+	n	E	Obs	O-C
408I.557	I5	-26I3	Diet.	-0.008	4983.386	I3	-242.5	BNN	+0.006
4087.46I	I5	-2597.5	Diet.	.000	4984.327	20	-240	BNN	- .005
48I2.57I	40	- 69I.5	MAT	+ .005	4989.472	I3	-226.5	BNN	+ .005
.578	22		FGR	+ .0I2	5003.339	II	-I90	BNN	- .0I4
.579	35		BSQ	+ .0I3	50I5.344	I5	-I58.5	BNN	+ .008
48I3.5I0	39	- 689	MAT	- .007	5022.370	2I	-I40	BNN	- .005
.5I2	I9		RAL	- .005	5075.6I9	9	0	LSP	- .0I7
.5I3	I9		GUI	- .004	.623	9	0	BNN	- .0I2
.529	34		BSQ	+ .0I2	5I69.584	2I	247	FGR	- .0I8
.529	28		FBG	+ .0I2	.6I2	7		BNN	+ .0I0
.53I	30		FGR	+ .0I4	5I73.585	I7	257.5	FGR	- .0I2
48I4.462	35	- 686.5	FBG	- .006	.592	I3		BEN	- .005
.463	27		RAL	- .005	.592	I5		RAL	- .004
.467	24		FGR	- .002	.60I	I9		FBG	+ .005
.467	25		NZY	- .002	.604	I6		BSQ	+ .007
.477	44		BSQ	+ .009	.606	8		BNN	+ .0I0
.480	5I		MAT	+ .0I2	5I74.536	I5	260	FND	- .0I2
.48I	24		GUI	+ .0I2	.544	27		BSQ	- .004
48I5.427	30	- 684	FBG	+ .007	.546	I5		GUI	- .002
.429	I9		GUS	+ .009	.548	23		FGR	.000
.43I	2I		FGR	+ .0II	.549	I6		RAL	+ .002
.432	2I		RAL	+ .0I3	.552	32		FBG	+ .005
.620	28		MAT	+ .0II	.556	I5		BNN	+ .008
.622	22		GUS	+ .0I2	.560	I8		BEN	+ .0I2
.625	26		RAL	+ .0I6	5I76.446	I5	265	FND	- .004
48I6.553	23	- 68I	GUS	- .008	.453	I4		BNN	+ .003
.556	23		RAL	- .005	.468	I5		BEN	+ .0I8
.557	I4		MAT	- .004	5I77.582	20	268	BSQ	- .0I0
.559	3I		BSQ	- .002	.588	I5		BEN	- .003
.560	26		FBG	- .00I	.589	I0		FND	- .002
.563	I9		FGR	+ .002	.590	I8		FBG	- .00I
.566	I5		NZY	+ .006	.59I	II		RAL	.000
48I9.398	I7	- 673.5	GUI	- .0I6	.593	20		FGR	+ .002
.403	2I		FBG	- .0II	.600	I5		BNN	+ .008
.4I5	I9		FGR	+ .00I	.60I	I5		GUI	+ .0I0
4822.637	22	- 665	MAT	- .0I0	5I78.54I	I4	270.5	RAL	- .002
.64I	I6		NZY	- .007	.544	23		BEN	+ .002
.646	22		BSQ	- .00I	.548	22		BSQ	+ .006
.65I	20		RAL	+ .004	.552	I4		BNN	+ .0I0
4834.435	40	- 634	GUS	- .006	.554	2I		FGR	+ .0I2
.440	24		BNN	- .002	5I93.57I	I2	3I0	BNN	+ .002
4835.384	I6	- 63I.5	LEY	- .009	5I97.550	I6	320.5	LSP	- .0I4
.386	I7		BNN	- .006	.56I	I5		BNN	- .003
.397	25		GUS	+ .005	5I99.456	23	325.5	BNN	- .0I0
4843.369	I8	- 6I0.5	BNN	- .0I2	.457	2I		LSP	- .009
4852.505	32	- 586.5	BNN	- .006	5202.504	I8	333.5	BNN	- .006
4866.384	I8	- 550	BNN	- .0I4	52I0.500	I0	354.5	FGR	+ .00I
4924.22I	7	- 398	BNN	- .002	5267.38I	I5	504	FGR	+ .008
.408	I0	- 397.5	BNN	- .006	5280.298	I4	538	BNN	- .0I0
4933.354	2I	- 374	BNN	+ .00I	5294.390	I4	575	FGR	+ .006
4958.258	I2	- 308.5	BNN	- .0I4	5343.274	I4	703.5	FGR	+ .004
.455	24	- 308	BNN	- .007	5369.33I	II	772	WLS	+ .00I

3.3 LO AND new ephemeris

Grouping the visual minima in four series (see Table 2), it was possible to calculate, for each of them ,provisional elements by a least-squares method. As the four results were similar, a final ephemeris was settled using all the I04 minima :

$$\text{J.D. hel.} \quad 24\,45\,075.6353 \quad + \quad 0.3804326 \quad E \qquad (2)$$
$$\pm 8 \qquad\qquad \pm 28$$

(95% confidence interval for the error bands)

The primary minimum (origin of the ephemeris) was not discriminated from the secondary. Examining each composite curve of the four more regular observers, it was possible to make a careful yet provisional choice. Unfortunately, it was not possible to refer to the single photoelectric curve of LO AND because it was incomplete.

It is important to note that the period,announced by A.GAUTSCHY,is not exactly half the one given in ephemeris (2). Apart from the short duration of the observational period (78 days) and the small number of timings, the difference could be explained by the flatness of the maxima, which introduces some inaccuracy in the timings.

3.4 Mean light curve

With the 2287 estimates from the four most active observers on this star (see Table 2), it was possible to plot a mean light curve (see Figure 2) based on the new ephemeris (2). All the estimates were averaged on intervals of 0.02 period. The 50 mean points are listed in Table 4.

φ	n	$\bar{m}$	φ	n	$\bar{m}$	φ	n	$\bar{m}$
0.0I	75	II.65	0.35	4I	II.35	0.69	40	II.29
0.03	78	II.59	0.37	38	II.40	0.7I	32	II.25
0.05	7I	II.54	0.39	40	II.40	0.73	36	II.27
0.07	6I	II.50	0.4I	49	II.44	0.75	40	II.28
0.09	50	II.44	0.43	38	II.46	0.77	30	II.25
0.II	56	II.42	0.45	48	II.53	0.79	37	II.28
0.I3	53	II.36	0.47	54	II.57	0.8I	30	II.32
0.I5	35	II.33	0.49	53	II.60	0.83	39	II.3I
0.I7	38	II.30	0.5I	54	II.60	0.85	42	II.34
0.I9	30	II.26	0.53	49	II.56	0.87	39	II.35
0.2I	34	II.26	0.55	55	II.53	0.89	54	II.39
0.23	33	II.28	0.57	50	II.48	0.9I	55	II.44
0.25	40	II.27	0.59	53	II.40	0.93	46	II.49
0.27	26	II.28	0.6I	3I	II.39	0.95	62	II.56
0.29	4I	II.3I	0.63	34	II.3I	0.97	62	II.62
0.3I	34	II.3I	0.65	42	II.30	0.99	74	II.63
0.33	44	II.32	0.67	42	II.3I			

Table 4: Phase (φ), number of estimates used (n), magnitude of each point of LO Andromedae mean light curve.

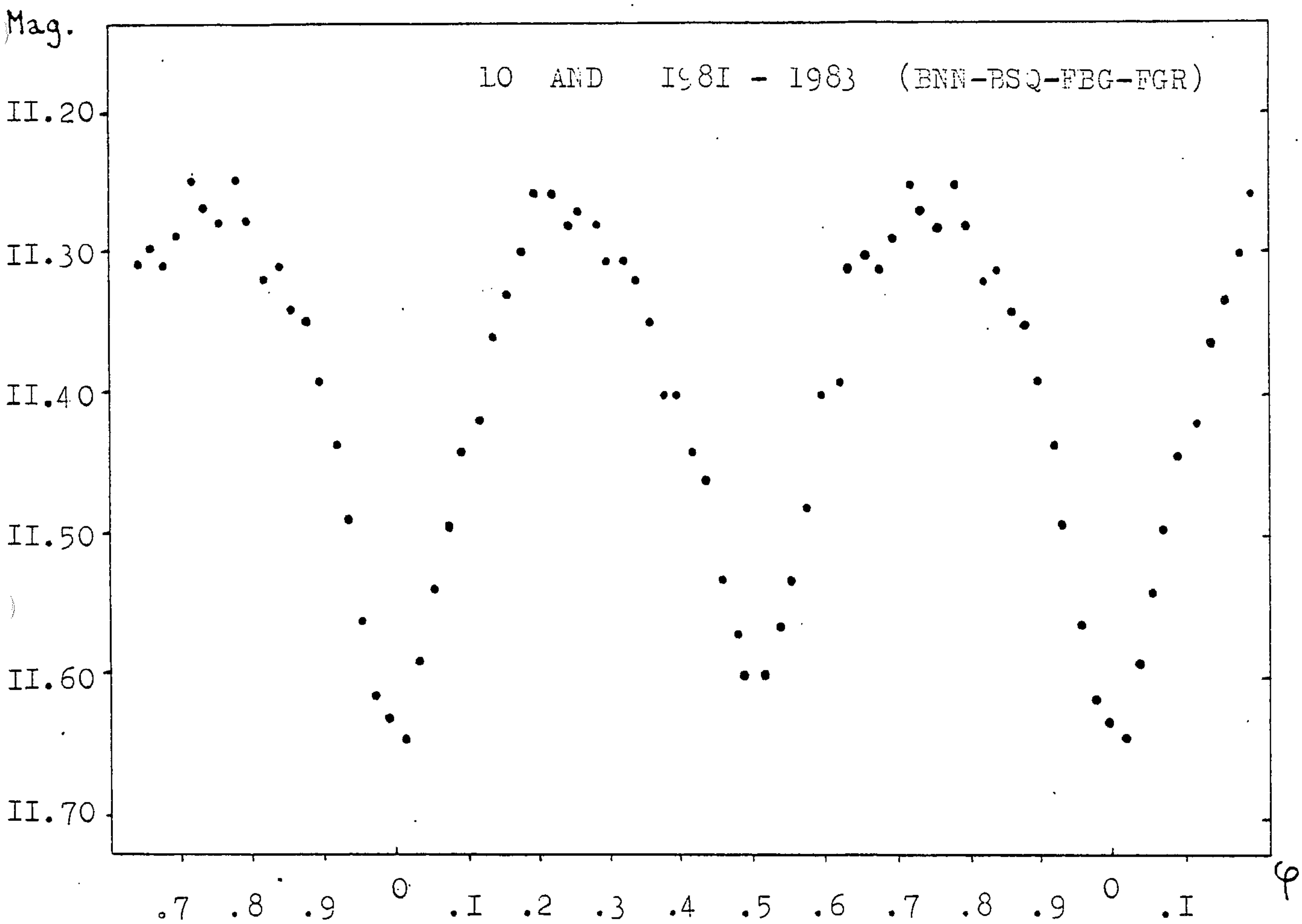

Figure 2: Mean light curve of LO Andromedae from 4 observers (R. Boninsegna, J. Busquets, J. Fabregat, A. Figer) according to ephemeris (2).

The real amplitude of the star, underestimated as is normal with a visual mean light curve, is probably around 0.5 - 0.6 magnitude. The brightness difference between primary and secondary minimum must be around 0.05 magnitude. Therefore, we can consider that LO Andromedae varies from II.20 to II.75 v with a secondary minimum at II.70 v. These values correspond well with those deduced from R.DIETHELM's photoelectric observations.

4. Conclusions

LO Andromedae is not a pulsating star but rather an EW eclipsing binary. The period announced by A.GAUTSCHY is roughly half the real period. The B-V mean value confirm our classification. A fairly accurate ephemeris is now available. The discrimination between primary and secondary minimum must be considered as temporary. Further visual observations will be necessary to improve the ephemeris, to check a possible variation of the O-C's and to confirm the character of the minima. More photoelectric observations would be important for the definitive discrimination of primary minima and for the computation of an accurate model for LO AND.

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