GEOS RR 4

GEOS CIRCULAR ON RR LYR TYPE VARIABLES

1982 June 10

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NEW MAXIMA OF CY AQUARII OBSERVED IN AUGUST 1980 AND ACCURATE DETERMINATION OF A MEAN MAXIMUM

ABSTRACT - CY Aqr was observed in August 1980 by 11 members of the GEOS (tab. 1), who collected more than 7500 visual estimates leading to the determination of 237 maxima (tab. 4). A statistical processing (tab. 2 & 3) enabled the influence of systematic errors to be considerably reduced : the standard deviations on timings of maxima are lower than 0.002 d. for the best observers. This led to the determination of a particularly accurate mean maximum : JDHel. 2 444 465.4526 ± 0.0003 d.

RESUMEN - CY Aqr fue observada en Agosto de 1980 por 11 miembros del GEOS (tab. 1) que reunieron más de 7500 estimaciones visuales, las cuales llevaron a 237 determinaciones de máximo (tab.4). El cálculo estadístico (tab. 2 & 3) permitió reducir al mínimo la influencia de los errores sistemáticos, y los mejores observadores alcanzaron una desviación-tipo inferior a 0.002 d. Esto condujo a la obtención de un máximo particularmente preciso : DJ Helio 2 444 465,4526 ± 0.0003 d.

RIASSUNTO - CY Aqr è stata osservata durante l' agosto 1980 da 11 membri del GEOS (tab.1) che hanno riunito più di 7500 stime visuali, che hanno permesso 237 determinazioni di massimi (tab. 4). Il calcolo statistico (tab.2 e 3) ha permesso di ridurre al minimo l'influenza degli errori sistematici ed i migliori osservatori raggiungono uno scarto quadratico medio inferiore a 0,002 g sui loro istanti di massimo. Ciò conduce ad ottenere un massimo medio particolarmente preciso : GG elioc. 2 444 465,4526 ± 0,0003 g.

RESUME - CY Aqr a été observée en Août 1980 par 11 membres du GEOS (tab. 1) qui ont réuni plus de 7500 estimations visuelles, permettant 237 déterminations de maxima (tab. 4). La méthode statistique utilisée (tab. 2 & 3) a permis de réduire au minimum l'influence des erreurs systématiques, et les meilleurs observateurs atteignent un écart-type sur leurs instants de maxima inférieur à 0,002 j. Ceci a conduit à l'obtention d'un maximum moyen particulièrement précis : JJ Hel. 2 444 465,4526 ± 0,0003 j.

1. LIST OF MAXIMA.

CY Aqr, an extremely rapid RRs, was abundantly observed at the GEOS camp held at Casinos (Valencia, Spain) and 7529 visual observations of the star were made between 1980 August 08 and 1980 August 19. These observations led to the determination of 237 maxima derived from the estimates made by 11 observers (tab. 1). The heliocentric maxima are given in tab. 4. The O-C's are referred to the ephemeris :
JD Hel. 2 441 959.4018 + 0.061 038 354 E
(Kukarkin, GCVS, 1976).

Mino BENUCCI	BEN	It. - Firenze
Jaime BUSQUETS	BSQ	Sp. - Valencia
Juan FABREGAT	FBG	Sp. - Valencia
Alain FIGER	FGR	Fr. - Paris
Jorge GOMEZ	GOM	Sp. - Valencia
Pascal GUIRAUDOU	GUI	Fr. - Montpellier
Edmond NEZRY	NZY	Fr. - Toulouse
Ennio PORETTI	POI	It. - Arconate
Philippe RALINCOURT	RAL	Fr. - Nantes
Joseph REMIS	RMS	Fr. - Aix
Stefano WABNITZ	WAB	It. - Roma

Tab. 1 : List of observers

2. DETERMINATION OF A MEAN O-C.

2.1. Arithmetic mean.

The arithmetic mean (unweighted) for all the O-C's is : $\overline{O-C} = -6.9 \times 10^{-4}$ d.

2.2. Weighted mean.

It is well known that visual observers can achieve various degrees of accuracy (Figer, 1975 ; Figer & Remis, 1978). It is therefore of interest to take this factor in consideration and calculate another mean for the O-C's, but this time weighted by a coefficient in $1/s^2$ and more accurate. In the present case it is quite possible to do so, as each observer covered a fairly important number of maxima and as the observers were fairly numerous. The standard deviation for each series are listed in tab. 2, where, following notations borrowed from Poretti (1981, GEOS EB 6) :

n_i is the number of maxima for each observer

$\overline{O-C}_i$ is the arithmetic mean of the O-C's for a given observer, related to the ephemeris given above

S_i is the standard deviation of the timings of a given observer :

$$S_i = \sqrt{\frac{\sum_{j=1}^{n_i} (O-C_j - \overline{O-C}_i)^2}{n_i - 1}}$$

P_i is the standard deviation of $\overline{O-C}_i$:

$$P_i = \frac{S_i}{\sqrt{n_i}}$$

W_i is the weight, to within a k coefficient, for the series i :

$$W_i = \frac{1}{(kP_i)^2}$$

	FGR	RAL	POI	GUI	BSQ	RMS	FBG	GOM	BEN	NZY	WAB
N_i	30	29	27	26	22	20	19	17	16	16	15
$\overline{O-C}_i \times 10^4$ d.	- 10.0	- 10.7	+ 2.1	- 15.6	- 3.5	- 9.7	- 0.8	+ 6.6	- 0.1	- 8.5	- 23.9
$S_i \times 10^4$ d.	15.1	14.2	18.8	18.8	21.4	18.9	38.2	26.9	33.0	18.5	18.1
$P_i \times 10^4$ d.	2.8	2.6	3.6	3.7	4.6	4.2	8.8	6.5	8.3	4.6	4.7
W_i	128	148	77	73	47	57	13	24	15	47	45

Tab. 2 : Standard deviations of the observers (iteration 0)

Each S_i is not very accurate, since it is estimated from a mean value derived from a small number of observations. Moreover, it is easily affected by systematic errors proper to the observer. In order to reduce these systematic errors, it is appropriate to average the results of all observers, but weighted by their own W_i. Thus doing, the mean $\overline{O-C}_w$ will then be derived from a much greater number of observations :

$$\overline{O-C}_w = \frac{\sum_{i=1}^{N} W_i \overline{O-C}_i}{\sum_{i=1}^{N} W_i}$$

and it will be more accurate as its standard deviation P_w will be much lower than P_i :

$$P_w = \frac{1}{\sqrt{\sum_{i=1}^{N} \left(\frac{1}{P_i}\right)^2}}$$

As a matter of fact, the results are : $\overline{O-C}_w = - 8.7 \times 10^{-4}$ d. $P_w = 1.3 \times 10^{-4}$d.

which must be compared to the unweighted mean of the O-C's (§ 2.1) : -6.9×10^{-4}d. One is thus led to note that several observers, among the less trained or the less productive, tend to see the maxima with a time-lag : this is a classical phenomenon in the field of visual observing of the RRs. This confirms the interest of the process used in this case as it enables this effect to be minimized.

2.3. Iterative processing.

The standard deviation of the maxima relative to each observer can be even better estimated, this time by using $\overline{O-C}_W$ as a reference instead of $\overline{O-C}_i$. This doing, one then gets values for S'_i, P'_i, W'_i after the first iteration :

	FGR	RAL	POI	GUI	BSQ	RMS	FBG	GOM	BEN	NZY	WAB
$S'_i \times 10^4$ d.	14.9	14.1	21.4	19.6	21.5	18.4	38.0	30.3	33.1	17.9	23.2
$P'_i \times 10^4$ d.	2.7	2.6	4.1	3.8	4.6	4.1	8.7	7.3	8.3	4.5	6.0
W'_i	137	148	59	69	47	59	13	19	15	49	28

Tab. 3 : Standard deviations of the observers (iteration 1)

It is not necessary to go beyond the first iteration as the variation of $\overline{O-C}_W$ is very small. Finally, the following value will be retained :

$$\overline{O-C}_W = -0.0009 \pm 0.0003 \text{ d.} \quad (2\,P_W)$$

3. MEAN MAXIMUM.

The mean maximum, derived from the mean O-C given above, is :

JD Hel 2 444 465.4526 ± 0.0003

P. Ralincourt

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FIGER A., REMIS J., 1978, GEOS Circ. SR 1 : "Courbe de lumière de OP Herculis".
KUKARKIN B.V. & al., 1976, GCVS.
PORETTI E., 1981, GEOS Circ. EB 6 : "List of minima and accurate determination of mean minimum for VW Cephei".
ROMOLI C., 1975, Sigma 1 : "Analisi di una serie d'osservazioni di CY Aquarii".

Date Aug.80	U.T.	Hel. J.D. - 2 444 000	O - C (day)	Observer
8	22 33	460.4448	- .0036	GUI
8	22 34.7	460.4460	- .0024	POI
8	22 38.7	460.4487	+ .0003	RAL
8	22 49	460.4559	+ .0075	BEN
9	0 03.7	460.5078	- .0016	GOM
9	0 04.3	460.5082	- .0012	RAL
9	0 05	460.5087	- .0007	GUI
9	0 05.4	460.5090	- .0004	FGR
9	0 08.2	460.5109	+ .0015	WAB
9	0 08.5	460.5111	+ .0017	NZY
9	0 11	460.5128	+ .0034	BEN
9	1 33.0	460.5698	- .0006	WAB
9	1 33.5	460.5701	- .0003	RAL
9	1 36	460.5719	+ .0015	GUI
9	1 36.2	460.5720	+ .0016	FGR
9	1 40.3	460.5749	+ .0045	POI
9	1 43	460.5767	+ .0063	BEN
9	2 58.6	460.6292	- .0023	FGR
9	3 00.0	460.6302	- .0013	POI
9	3 04	460.6330	+ .0015	BEN
9	3 04.5	460.6333	+ .0018	RAL
9	3 05.2	460.6338	+ .0023	GUI
10	22 53.6	462.4591	- .0035	GUI
10	22 58.6	462.4626	.0000	FGR
10	22 59.6	462.4633	+ .0007	RMS
10	23 04.9	462.4669	+ .0043	GOM
10	23 05.2	462.4671	+ .0045	BSQ
11	0 24.8	462.5224	- .0013	GUI
11	0 27.5	462.5243	+ .0006	FGR
11	0 28.5	462.5250	+ .0013	RMS
11	0 30.4	462.5263	+ .0026	BSQ
11	0 33.0	462.5281	+ .0044	GOM
11	1 45.1	462.5782	- .0065	FBG
11	1 50.5	462.5819	- .0028	FGR
11	1 51.2	462.5824	- .0023	RAL
11	1 51.7	462.5828	- .0019	GOM
11	1 52.2	462.5831	- .0016	BSQ
11	1 53.8	462.5842	- .0005	POI
11	1 54.7	462.5849	+ .0002	NZY
11	1 56.0	462.5858	+ .0011	RMS
11	1 56.7	462.5862	+ .0015	GUI
11	3 17.2	462.6421	- .0036	GOM
11	3 21.5	462.6451	- .0006	FGR
11	3 22.7	462.6460	+ .0003	POI
11	3 25.0	462.6476	+ .0019	BSQ
11	3 25.1	462.6476	+ .0019	RAL
11	3 25.9	462.6482	+ .0025	GUI
11	3 26.5	462.6486	+ .0029	NZY
11	23 49.4	463.4979	- .0024	RAL
11	23 50.1	463.4984	- .0019	GUI
11	23 53.2	463.5006	+ .0003	FGR
11	23 55.4	463.5021	+ .0018	POI
11	23 56.0	463.5025	+ .0022	BSQ
11	23 56.8	463.5031	+ .0028	GOM
11	23 59.1	463.5047	+ .0044	RMS
12	0 04.3	463.5083	+ .0080	FBG
12	1 17.2	463.5589	- .0024	GUI
12	1 17.8	463.5593	- .0020	NZY
12	1 18.3	463.5597	- .0016	FGR
12	1 18.8	463.5600	- .0013	RAL
12	1 19.5	463.5605	- .0008	POI
12	1 20.8	463.5614	+ .0001	FBG
12	1 21.5	463.5619	+ .0006	RMS
12	1 23.3	463.5631	+ .0018	GOM
12	1 25.8	463.5649	+ .0036	BSQ
12	2 42.8	463.6184	- .0039	NZY
12	2 47.4	463.6216	- .0007	FGR
12	2 47.5	463.6216	- .0007	RMS
12	2 47.6	463.6217	- .0006	GUI
12	2 49.1	463.6227	+ .0004	BSQ
12	2 49.2	463.6228	+ .0005	POI
12	2 50.3	463.6236	+ .0013	RAL
12	2 51.0	463.6241	+ .0018	FBG
12	2 54.2	463.6263	+ .0040	GOM
12	21 47.8	464.4135	- .0023	GUI
12	21 50.4	464.4153	- .0005	POI
12	21 51.4	464.4160	+ .0002	RAL
12	21 52.0	464.4164	+ .0006	FGR
12	23 15.3	464.4743	- .0026	GUI
12	23 17.0	464.4754	- .0015	BEN
12	23 17.0	464.4754	- .0015	NZY
12	23 17.1	464.4755	- .0014	WAB
12	23 17.4	464.4757	- .0012	FBG
12	23 17.8	464.4760	- .0009	RMS
12	23 18.1	464.4762	- .0007	BSQ
12	23 18.7	464.4766	- .0003	RAL
12	23 20.0	464.4775	+ .0006	FGR
12	23 22.1	464.4790	+ .0021	POI
13	0 42.8	464.5350	- .0029	WAB
13	0 44.8	464.5364	- .0015	GUI
13	0 45.0	464.5366	- .0013	POI
13	0 45.1	464.5366	- .0013	RAL
13	0 45.8	464.5371	- .0008	BEN
13	0 45.8	464.5371	- .0008	RMS
13	0 46.6	464.5377	- .0002	BSQ
13	0 46.6	464.5377	- .0002	NZY
13	0 47.0	464.5379	.0000	FGR
13	0 55.1	464.5436	+ .0057	FBG
13	2 10.6	464.5960	- .0030	GUI
13	2 10.7	464.5961	- .0029	POI
13	2 11.9	464.5969	- .0021	NZY
13	2 11.9	464.5969	- .0021	WAB
13	2 12.3	464.5972	- .0018	BEN
13	2 12.8	464.5975	- .0015	RAL
13	2 13.0	464.5977	- .0013	BSQ
13	2 13.2	464.5978	- .0012	RMS
13	2 14.4	464.5986	- .0004	FBG
13	2 15.7	464.5995	+ .0005	FGR
13	3 34.9	464.6545	- .0055	WAB
13	3 38.5	464.6570	- .0030	FGR
13	3 38.9	464.6573	- .0027	RMS
13	3 40.4	464.6584	- .0016	RAL
13	3 41.5	464.6591	- .0009	NZY
13	3 42.7	464.6600	.0000	FBG
13	3 44.0	464.6609	+ .0009	BSQ
13	3 44.1	464.6609	+ .0009	GUI
15	23 00.8	467.4643	- .0035	RAL
15	23 03.5	467.4662	- .0016	FGR

Tab. 4 : Heliocentric maxima (1/2)

Date Aug.80	U.T.	Hel. J.D. - 2 444 000	O - C (day)	Observer
15	23 10.6	467.4711	+ .0033	POI
16	0 31.8	467.5275	- .0013	FGR
16	0 32.4	467.5279	- .0009	RAL
16	0 33.4	467.5286	- .0002	POI
16	0 34.2	467.5292	+ .0004	FBG
16	20 59.5	468.3801	- .0032	BSQ
16	21 00.4	468.3807	- .0026	FGR
16	21 02.0	468.3818	- .0015	RMS
16	21 02.8	468.3823	- .0010	RAL
16	21 03.0	468.3825	- .0008	GUI
16	21 04.1	468.3832	- .0001	POI
16	22 23.2	468.4382	- .0062	FBG
16	22 26.7	468.4406	- .0038	GUI
16	22 27.2	468.4410	- .0034	WAB
16	22 27.7	468.4413	- .0031	BSQ
16	22 28.2	468.4417	- .0027	NZY
16	22 28.9	468.4421	- .0023	RAL
16	22 29.9	468.4428	- .0016	FGR
16	22 30.5	468.4432	- .0012	RMS
16	22 33.0	468.4450	+ .0006	BEN
16	22 33.7	468.4455	+ .0011	POI
16	22 36.0	468.4471	+ .0027	GOM
16	23 55.2	468.5021	- .0033	GUI
16	23 55.8	468.5025	- .0029	RAL
16	23 56.0	468.5026	- .0028	NZY
16	23 56.4	468.5029	- .0025	FGR
16	23 56.8	468.5032	- .0022	FBG
16	23 57.0	468.5033	- .0021	RMS
16	23 57.3	468.5035	- .0019	BEN
16	23 57.8	468.5039	- .0015	BSQ
16	23 57.8	468.5039	- .0015	WAB
17	0 01.3	468.5063	+ .0009	GOM
17	0 01.8	468.5067	+ .0013	POI
17	1 22.3	468.5626	- .0039	RMS
17	1 22.8	468.5629	- .0036	FBG
17	1 23.7	468.5635	- .0030	WAB
17	1 24.3	468.5639	- .0026	NZY
17	1 24.3	468.5639	- .0026	GUI
17	1 24.5	468.5641	- .0024	BEN
17	1 24.7	468.5642	- .0023	BSQ
17	1 25.3	468.5646	- .0019	POI
17	1 25.6	468.5648	- .0017	RAL
17	1 25.7	468.5649	- .0016	FGR
17	1 28.9	468.5671	+ .0006	GOM
17	2 47.6	468.6218	- .0057	FBG
17	2 49.8	468.6233	- .0042	WAB
17	2 50.2	468.6236	- .0039	BEN
17	2 52.0	468.6248	- .0027	FGR
17	2 52.8	468.6254	- .0021	RAL
17	2 53.3	468.6257	- .0018	GUI
17	2 53.4	468.6258	- .0017	BSQ
17	2 53.4	468.6258	- .0017	RMS
17	2 56.0	468.6276	+ .0001	POI
17	2 59.7	468.6302	+ .0027	GOM
17	21 53.5	469.4177	- .0033	GUI
17	21 54.1	469.4181	- .0029	FGR
17	21 54.2	469.4181	- .0029	WAB
17	21 55.5	469.4190	- .0020	RAL
17	21 56.9	469.4200	- .0010	POI
17	21 56.9	469.4200	- .0010	RMS
17	21 57.3	469.4203	- .0007	BEN
17	21 57.8	469.4206	- .0004	NZY
17	21 57.9	469.4207	- .0003	BSQ
17	21 59.2	469.4216	+ .0006	FBG
17	22 01.7	469.4233	+ .0023	GOM
17	23 21.6	469.4788	- .0032	GUI
17	23 22.0	469.4791	- .0029	RMS
17	23 22.4	469.4794	- .0026	FGR
17	23 23.5	469.4802	- .0018	BSQ
17	23 23.5	469.4802	- .0018	RAL
17	23 24.4	469.4808	- .0012	GOM
17	23 24.9	469.4811	- .0009	NZY
17	23 25.0	469.4812	- .0008	BEN
17	23 25.6	469.4816	- .0004	POI
17	23 26.7	469.4824	+ .0004	WAB
17	23 30.2	469.4848	+ .0028	FBG
18	0 49.0	469.5395	- .0036	BEN
18	0 49.2	469.5397	- .0034	WAB
18	0 50.4	469.5405	- .0026	RMS
18	0 50.7	469.5407	- .0024	GUI
18	0 51.1	469.5410	- .0021	BSQ
18	0 51.2	469.5411	- .0020	GOM
18	0 51.7	469.5414	- .0017	POI
18	0 52.7	469.5421	- .0010	FGR
18	0 52.8	469.5422	- .0009	RAL
18	0 53.9	469.5429	- .0002	FBG
18	0 54.6	469.5434	+ .0003	NZY
18	2 17.1	469.6007	- .0034	WAB
18	2 17.7	469.6011	- .0030	GOM
18	2 17.8	469.6012	- .0029	RMS
18	2 18.0	469.6013	- .0028	BEN
18	2 18.5	469.6017	- .0024	FGR
18	2 19.6	469.6024	- .0017	BSQ
18	2 21.7	469.6039	- .0002	POI
18	2 22.8	469.6047	+ .0006	RAL
18	2 28.8	469.6088	+ .0047	FBG
18	3 44.9	469.6617	- .0034	WAB
18	3 46.0	469.6624	- .0027	FGR
18	3 46.0	469.6624	- .0027	GUI
18	3 47.2	469.6633	- .0018	BSQ
18	3 47.8	469.6637	- .0014	RMS
18	3 48.8	469.6644	- .0007	POI
18	3 49.7	469.6650	- .0001	RAL
18	3 50.4	469.6655	+ .0004	FBG
18	3 50.8	469.6658	+ .0007	BEN
18	3 51.7	469.6664	+ .0013	NZY
18	21 21.9	470.3957	- .0019	GUI
18	21 23.6	470.3969	- .0007	FGR
18	21 23.9	470.3971	- .0005	RAL
18	21 24.6	470.3976	.0000	POI
18	22 49.6	470.4566	- .0020	GOM
18	22 50.5	470.4572	- .0014	RAL
18	22 51.6	470.4580	- .0006	BSQ
18	22 52.5	470.4586	.0000	FBG
18	22 55.9	470.4610	+ .0024	FGR
18	22 58.7	470.4629	+ .0043	POI
19	0 15.0	470.5159	- .0038	RAL
19	0 21.9	470.5207	+ .0010	FGR
19	0 23.8	470.5220	+ .0023	POI

Tab. 4 : Heliocentric maxima (2/2)