COMMISSION 27 OF THE I. A. U.
INFORMATION BULLETIN ON VARIABLE STARS
NUMBER 442

Konkoly Observatory
Budapest
1970 July 2

FLARE ACTIVITY OF -32°16135, YZ CMi AND LPM 63

YZ CMi

Continuous U-band photometry of flare activity on YZ CMi was carried out in late 1969 and early 1970 so as to correspond as closely as possible to the effort of the working group on flare stars of I.A.U. commission 27. 63 flares were observed in a total of 27.5 hours of monitoring.

Observing and data processing methods are identical to those described earlier (Kunkel, 1968). In addition to the data presented earlier, the areas under the flare light curves were planimetered to derive a measure of the total energy radiated by a flare. It could not be shown that these measures are free from systematic bias. This bias takes the form of underestimating the flare areas of weaker events. The origin of the problem lies in the difficulty of locating the quiescent level in the presence of (1) noise from the discrete photoelectric process and (2) slow stationary variations in light which affect some stars significantly more than others. Since the bias is dependent on signal amplitudes, it clearly depends also on the telescope aperture and photometric band used. Only those measures of the integrated intensity are given where there is some assurance that the underestimate is less than five percent. These estimates appear in column 9 of the flare abstract, according to

$$P = \frac{I}{I_o} \int (I_f - I_q)\, dt \text{ minutes},$$

where I_f is the record of combined flare light and quiescent light, I_q is nominally the quiescent light, which in practice consists of all light not attributed to the flare under study, and I_o is an estimate of the true quiescent light (absence of any flare activity whatever is assumed). I_q and I_o are generally different: I_q is measured directly from the chart near the event studied, while I_o is determined by examining the probability distribution of the U-light of the stars from several nights, referenced to comparison stars. The value selected is that which appears to correspond to a total absence of any activity on the star. For YZ CMi (Epoch 1970.0) I_o has been chosen to correspond to U_o=13.85.

Observing was done in two runs separated by about 40 days. Originally it had been intended to combine the data from both to form a single estimate of flare activity at Epoch 1970.0. Activity during the later run was markedly weaker, so that each run was processed separately, at a loss of accuracy incurred by the reduced sample size. The flare incidence equation

$$R(u) = \exp\left[a(u - u_o)\right] \text{ events per hour}$$

shows the phenomenon clearly in the differing values of u_o; (values of $\underline{a}$ are sufficiently similar so as to influence the estimate of change in flare activity very little).

Table I. Activity on YZ Canis Minoris

Epoch	Sample Size		U_{lim}	a	u_o	Remarks
	Hours	Events				
1969.97	16.06	25	15.0	.87	14.65	24-inch reflector
1970.08	11.44	30	16.0	1.03	15.26	36-inch reflector

Graphically the result is shown in figure 1, a plot of the flare magnitude at peak light, u, as a function of the rate R(u). Data from the earlier and later epoch are shown by circles and crosses, respectively.

Tabulated in the flare abstract for each night are (columns 1, 2, and 3) the event U.T., the airmass, and the U-magnitude at peak light (quiescent light I_q subtracted). Columns 4 and 5 list the flare durations at 0.5 and 0.1 peak light, respectively. Flare decay rates at 1, 2, and 3 magnitudes below peak light are listed in columns 6, 7, and 8, respectively. They are expressed as the common logarithm of the decay in magnitudes per minute. A colon has been used whenever uncertainty in an estimate was judged to exceed 10 percent. The letter "c" has been used to denote a complex time history affecting the estimate, so that its numerical value may have little significance. The integrated intensity P is given in column 9, in minutes of time. No description of flare rise characteristics has been attempted, since instrumental limitations tend to distort the later portions of the rise in the more rapid events.

Completeness of the record is controlled as before (Kunkel 1968), except that now the level of 90 percent completeness is given by U_{lim} as in Table 1.

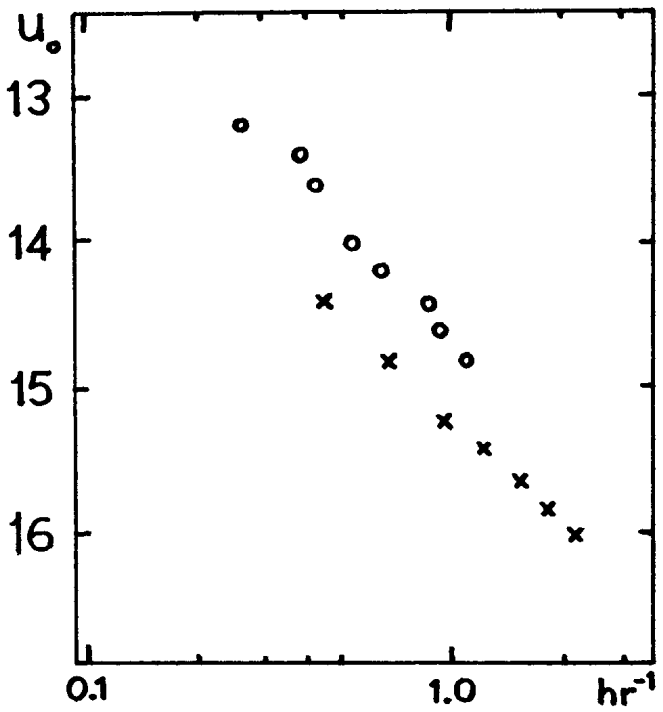

Figure 1

Flare incidence of YZ CMi, Data for fewer than five flares are not shown. Circles represent epoch 1969.97 observations, and crosses represent observations of epoch 1970.08.

Flare Abstract, YZ Canis Minoris

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	P
18 Dec.1969 $04^h02.4-07^h39.9$			k_u=0.58, 7 events					T=3.625
$4^h35^m.78$	1.41	14.92	2.2	-	-			-
5 16.55	1.285	12.98	.87	4.8	-.07	-.20	-.9:	4.16
6 19.71	1.21	14.90	.27	-	-			-
6 37.78	1.21	15.5	.3:		-			-
6 52.48	1.21	13.87	.40	c	-.21			note 1
6 55.97	1.21	14.26c	.6	-	-			note 1
6 58.3	1.21	14.39c	3.7	-	-			note 1
19 Dec.1969 $03^h36^m.2-08^h01^m.7$			k_u=0.53,		10 events			T=4.423
$3^h54^m.45$	1.58	13.93	1.8	-	-.20	-.71	-	2.51
4 11.06	1.49	14.81	.3		-			-
4 32.12	1.40	14.84	.25		-			-
5 17.21	1.275	14.12	.08	2.:	+.86	-.46		-
5 32.78	1.25	11.43	.16	2.1	+.55	+.47	-.49	5.33
6 13.73	1.21	13.24	.65	7.2	-.04	-.73	-.80	4.16
6 22.35	1.21	15.24	.65		-			-
6 35.00	1.21	14.50	.22		+.52			-
7 41.5	1.26	15.72	1.3:		-			-
7 45.10	1.27	13.26	1.7	10.6	-.23	-.42	-.72:	1.99
20 Dec.1969 $04^h40^m.4-08^h04^m.4$			k_u=0.51,		7 events			T=3.400
$4^h44^m.0$	1.34	<15.03	-		-			note 2
5 32.02	1.245	14.12	.55		-.05			-
6 53.29	1.21	13.87	.50	c	-.01	-.64:		2.05
7 05.70	1.22	14.16	.55	c	-.35	c		1.11
7 07.88	1.22	13.14	.41	3.2	+.06	-.52c	-.9:	2.58
7 15.23	1.24	14.94	.28		-			-
7 39.16	1.27	12.53	.62	5.8	-.07	-.66	-1.1	9.27
21 Dec.1969 $03^h39^m.0-08^h15.6$			k_u=0.58,		5 events			T=4.61
$3^h53^m.50$	1.54	13.29	.11	.44	-			-
4 16.30	1.42	14.71:	.5:		-			-
4 54.86	1.31	14.56	.25		-			-
6 04.25	1.21	13.54	.15	3.	+.05	-.53c	-	1.33
8 02.70	1.33	13.03	.28	1.6	.00	+.10		2.93
27 Jan.1970 $02^h21^m.3-06^h41.2$			k_u=0.55,		12 events			T=4.33
$2^h27^m.5$	1.31	15.95	3.6		-			-
2 36.52	1.29	14.62	.59	2.5	+.02			-
2 42.55	1.28	15.27	.54		-.04:			-
3 32.69	1.21	15.97	2.5:		-			-
3 36.32	1.21	15.25	.23		+.12:			-
3 55.63	1.21	13.01	1.27	5.6	-.54	-.44	-.57	5.36

Flare Abstract, YZ Canis Minoris (Cont.)

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	P
27 Jan.1970, continued								
$4^h33^m.50$	1.22	15.98	.9:		–			–
4 49.14	1.24	14.75	.18	c	+.11	-.26	c	
5 21.67	1.29	14.24	.17	.83	+.70	+.13:		–
5 28.5:	1.31	<12.36	<.3:		+.55:	-.56:	-.62:	note 3
5 44.76	1.36	15.25	.40	c	+.19			–
6 31.97	1.56	15.18	.42		–			–
28 Jan.1970 $2^h42^m.2$-$4^h46^m.1$ and $4^h49^m.3$-$6^h24^m.6$ k_u=.52, 14 events $T=3^h.82$								
$2^h53^m.65$	1.23	15.09	.23c		c			–
2 57.56	1.23	14.34	.27	1.14	+.72	+.08		–
3 04.9	1.22	16.03	1.3:		–			–
2 48.60	1.24	15.88	.55		–			–
3 32.94	1.21	16.37	.35		–			–
4 29.13	1.22	15.12	.20		+.49			–
4 31.91	1.22	15.51	.55:		–			–
4 35.46	1.23	15.29	.95		-.51:			–
5 01.01	1.26	14.30	.24		–			note 4
5 19.24	1.30	15.66	.23		–			–
5 25.76	1.31	14.77	.23	1.65	+.16	-.26:		–
5 33.73	1.33	15.75	.29		–			–
5 36.31	1.34	15.13	2.1:		-.54			–
6 12.3	1.47	16.18	3.6		–			–
29 Jan.1970 $3^h05^m.5$-$6^h25^m.5$, k_u=0.61 9 events $T=3^h.29$								
3^h20^m	1.21	15.43	8.6		-.94			note 5
3 38.1	1.21	15.92	1.2:		–			–
4 34.3	1.23	15.68	.36		–			–
4 35.2	1.23	15.53	.52		–			–
4 51.3	1.26	16.04	3.:		–			–
4 54.56	1.26	14.24	.55	c	+.60	.0:		–
5 46.7	1.39	16.31	2.1		–			–
5 54.36	1.42	15.70	.6		–			–
6 17.8	1.47	15.43	.95		–			–

Notes

1) These three events form peaks on a general rise in light. Together their combined integrated intensity is 6.09.
2) Peak was lost while taking sky measure.
3) Peak was lost while taking sky measure; decay rates, while accurately measured, where referenced to a presumed peak of 12.06. Integrated intensity was larger than 6.40.
4) This event had a decline as rapid as the rise: a spike; rare.
5) This is the slowest event recorded. $T_{0.2} > 23$ minutes.

-32°16135A,B = Gliese 799

As on a past occasion (Kunkel, 1969) this star has shown itself as the most active flare star so far observed. So pronounced is the activity that for more than half of the monitoring time the contribution of flare light to the U-band was greater than 0.05 magnitudes. 54 flares were recorded in 16.31 hours, of which 49 were brighter than U_{lim}=15.8. The activity during this run (Epoch 1969.70) is not significantly different from that recorded earlier (Epoch 1967.72). The flare incidence parameters, based on events fainter than U=13.8 are a=0.67 and u_o=14.11. A plot of R(u) (see figure 2) shows an apparent deficiency in flares brighter than u=13.8; the change of slope is nearly a factor of two. The number of events contributing to the bright portion of the curve is too small, however, to permit an inference that the phenomenon may be attributed to activity of the star in general. The 1967 do not show it, for instance.

Data for individual flares are presented as for YZ CMi. The 90 percent completeness level has been put at U_{lim}=15.8. No integrated intensities are given because the difficulty in locating the quiescent level is extreme, many flares occurring during the decline of one or more preceding events.

Quiescent level magnitudes and colors are V=10.22±.02, B-V=1.59±0.01, and U-B=1.09±03.

Flare Abstract, -32°16135

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	Notes
12 Sept. 1969		$0^h04^m.8$-$3^h24^m.7$ and $3^h28^m.5$-$6^h02^m.8$, k_u=.52						
		18 events	T=$4^h.90$					
$0^h38^m.06$	1.05	15.16	.4		-			
0 42.96	1.04	14.9:	.35		-			note 1
0 45.37	1.04	14.04	1.2	21	-.65	-.88:		
1 11.60	1.02	15.51	1.2:		-			
1 29.8:	1.00	16.37	3:		-			note 2
1 57.3	1.00	16.17	5.5:		-			note 2
2 19.5	1.00	16.02	4:		-			
2 28.7	1.01	15.70	3.0		-			
2 39.7	1.01	14.72	12	27.:	-1.06	-.82::		note 3
2 43.97	1.02	15.08	.4		-.24			note 4
2 49.7	1.02	15.76	1.2		-			
2 59.72	1.03	13.39	.25	8.5	+.33	-.72	-1.11	
3 17.4	1.04	15.39c	.9c		-			note 1
3 28.4	1.06	<13.68	-	-	(-.16)	(-1.13)		note 5

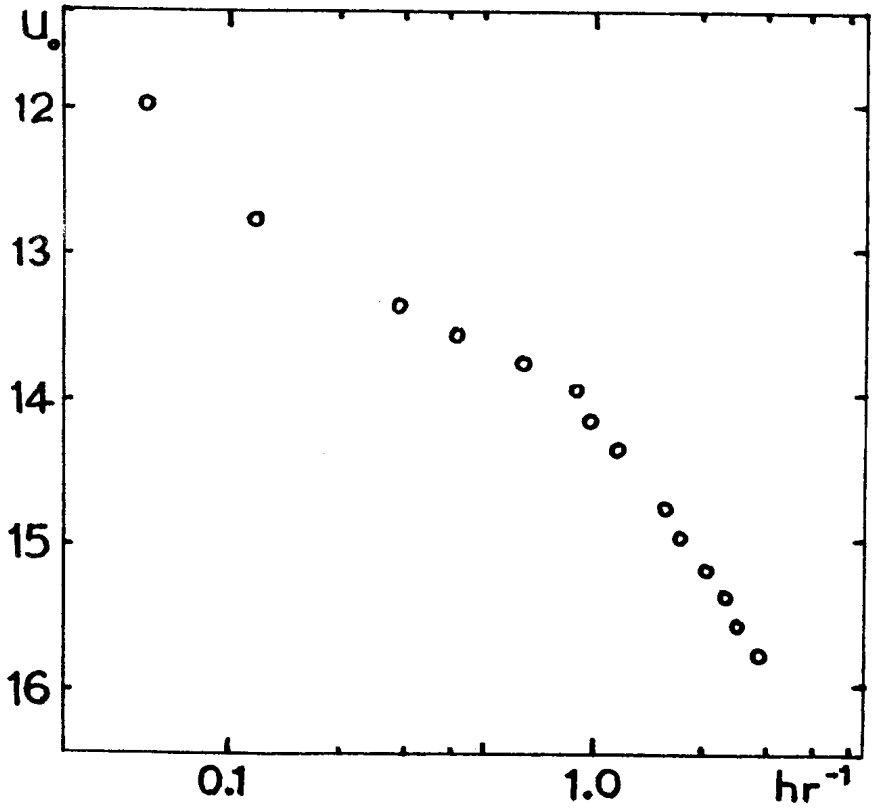

Figure 2

Flare incidence of -32°16135A,B, epoch 1969.70 for both stars together. The abcissa is the frequency in events per hour brighter than magnitude u_o, the ordinate.

Flare Abstract, -32°16135 (Cont.)

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	Notes
12 Sept.1969, continued								
$3^h54.42$	1.10	13.79	1.0	c	+.01	c		note 6
3 56.94	1.11	14.11	3.0:		c	-.85:		note 4
4 20.8	1.16	15.66	2.4:		-			
5 07.40	1.30	14.21	1.4	6.8	-.17	-.21		
13 Sept.1969 $0^h13^m.8$-$5^h04^m.0$ and $5^h10^m.6$-$5^h57^m.2$, k_u=.54 16 events T=$5^h.61$								
$0^h15^m.57$	1.07	13.26	.67	c	-.91	-1.38	c	note 7
0 50.31	1.03	13.90	2.25		-.41	-.81		
1 16.15	1.01	13.81	2.2	15.5:	-.57	-1.05		
2 10.5	1.00	13.96	1.8	12.3:	-.23	-.94		
2 41.75	1.02	15.65	6.:		-			note 2
2 44.14	1.02	15.17	.35		-			note 4
2 56.5	1.03	15.97	3.:		-			note 4
3 02.38	1.03	15.47	1.1		-			
3 09.0	1.04	15.69	1.7		-			
3 43.03	1.09	14.97	2.3		-.70			
3 52.6	1.11	15.65	6.0	13.	-			
4 30.22	1.19	13.46	1.95	16.c	-.61	-1.15	-1.1:	
4 37.85	1.22	12.77	.38	.85	+.68	+.27	-.31	note 4
5 11.60	1.34	13.64	.87	c	+.23	c		note 1
5 14.7	1.35	13.75	4.1	27.9	-.75	-1.26		
5 26.28	1.41	13.28	.94	4.5	-.19c	-.33	-.59	
14 Sept.1969 $0^h01^m.6$-$4^h54^m.0$ and $4^h58^m.7$-$5^h54^m.2$, k_u=.52 20 events T=$5^h.80$								
$0^h14^m.74$	1.07	13.56	.55	1.9	+.47	+.05	c	
0 18.0	1.06	15.29	2.2		-.36:			
0 25.98	1.05	15.33	1.5		-			
0 45.8	1.03	15.50	4.8		-			note 2
1 12	1.01	13.01	13.:		-			note 2
1 14.86	1.01	14.32	.11	2.6	+.34	-.31		note 4
1 24.13	1.00	15.35	.7		-			
1 27.75	1.00	14.61	1.8	10.2	-.46	-.78		
2 00.0	1.00	14.80	15		-1.27			note 2
2 23.1	1.01	14.83	25.3c		-1.45			note 8
2 31.9	1.01	14.75						
3 03.75	1.02	14.66	1.7		-.29			
3 37.05	1.08	11.69	4.6	25.	-.39	-.84	-1.51c	note 9
3 50.05	1.10	13.71	.4	c	+.20	-.10		note 4
3 54.20	1.12	14.65	1.1		-			

Flare Abstract, -32°16135 (Cont.)

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	Notes
14 Sept. 1969, continued								
$4^h05.88$	1.14	14.69	.27					
4 29.53	1.20	15.05	.25					
4 33.2	1.22	15.49	1.2					
5 18.12	1.37	15.08	2.1					
5 41.25	1.52	14.28	.17	9.6:		c	-.93	

Notes
1) On rising part of the following flare
2) Slow event of long duration with smooth, rounded peak.
3) τ_2 measured near next following event.
4) Superposed on a previous event of slow decline.
5) Peak lost on sky measure.
6) Decline covered by following flare.
7) Quiescent level uncertain.
8) Very slow flare. The two events ($2^h23^m\!.1$ and $2^h31^m\!.9$) appear to be peaks of the same protracted event.
9) The measure for τ_3 is covered by the next three events. A measure of τ_4=-1.1.

LPM 63 = Gliese 54.1

This is the least active flare star so far monitored from Cerro Tololo. Data are sufficient to yield only a preliminary incidence function R(u). In 12 hours of monitoring with the 36-inch reflector only seven events were recorded brighter than U_{lim}=17.0. The somewhat uncertain estimates of the incidence parameters are a=0.9 and u_o=17.0, the lowest value ever recorded. The rate growth coefficient a appears quite average, and is not likely to be in error by more than 0.15, while the probable error on u_o is about 0.2 magnitudes. A plot of the flare data appears in figure 3.

A listing of individual flares, under the same controls as given before, follows.

Flare Abstract, LPM 63

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	Notes
13 Sept.1969	$06^h47^m.2$-$09^h25^m.1$	k_u=.54	2 events	T=$2^h.63$				
$9^h11.1$	1.29	15.91	1.15		-.10			
9 16.0	1.31	16.05	.9		-.29			
14 Sept.1969	$3^h35^m.0$-$7^h14^m.4$ and $7^h16^m.4$-$9^h21^m.1$	k_u=.52	1 event	T=$2^h.73$				
$6^h55^m.10$	1.04	14.82	.4	5.	+.61	-.14	-.82	note 1
16 Sept.1969	$2^h36^m.1$-$5^h12^m.4$ and $5^h16^m.1$-$9^h14^m.5$	k_u=.55	4 events	T=$6^h.58$				
$3^h40^m.30$	1.25	15.88	.4	13.5:	+.19:			
6 35.62	1.02	16.10	.83	9.1	+.09	-.45:		
6 56.55	1.03	16.98	.7		-			
8 29.7	1.20	16.78	.95		-			

note 1) A long standstill $1^m.7$ magnitude below peak light lasting three minutes made measurement of τ_2 difficult.

Contribution from the Cerro Tololo Inter-American Observatory No.117

Observatorio Interamericano de Cerro Tololo*

1970 June 13

WILLIAM E. KUNKEL

* Operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

References

Kunkel,W.E., 1968 I.B.V.S. No.315
Kunkel,W.E., 1969 Bull. A.A.S. 1, 197

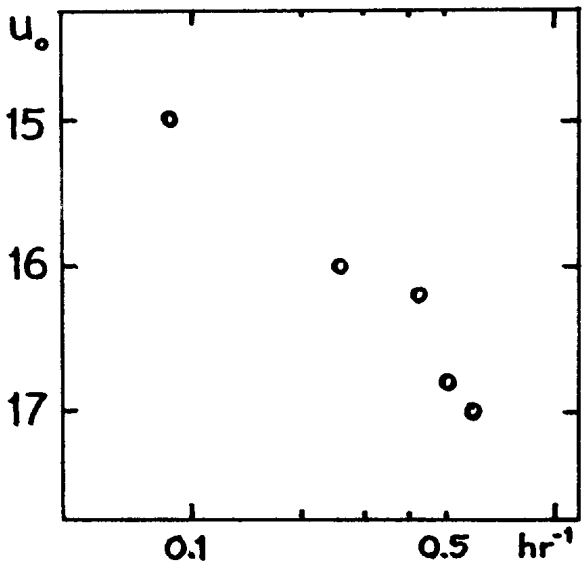

Figure 3
Flare incidence of LPM 63, epoch 1969.70