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FLARE ACTIVITY OF PROXIMA CENTAURI, 1969

Flare activity of Proxima Centauri was discovered by Shapley (1949, 1951, 1954) from a search of Harvard plate material. The activity reported is considerable, with Δm_{pg} greater than 0.5 magnitudes about six percent of the time. Photoelectric monitoring of Proxima was initiated at Cerro Tololo in 1969 to determine the present level of activity, and further, to expand the meager data on flare activity of the least luminous flare stars.

A listing of events recorded in 23.6 hours of U-band photometry during the 1969 observing season appears in table 2, following observational procedures described elsewhere (Kunkel 1968). A 90-cm reflector was used on the first two nights, and one of 40-cm aperture on the remaining nights. Comparison stars listed in table 1 and identified in figure 1 were used on all nights. Probable errors in V and (B-V) are 0.01,

Table 1. Comparison Stars for Proxima

Star	V	B-V	U-B
A	11.77	0.85	0.54
B	11.75	0.20	-0.33
C	11.33	0.75	0.26

and in (U-B) 0.015 magnitudes.

Given for each night in table 2 are the event U.T., the corresponding airmass, and the U-magnitudes at peak light, columns (1) through (3). Columns (4) and (5) list the durations at 0.5 and 0.1 peak light, respectively. R.m.s. uncertainties greater than ten percent are indicated by a colon. Decay rates at 1, 2, and 3 magnitudes below peak

light appear in columns (6) through (8). They are expressed as the common logarithm of the decay in magnitudes per minute. A colon is used to indicate r.m.s. uncertainties greater than 0.1. A letter "c" indicates a complex time-history, such as events with multiple peaks or rapid changes in slope, denoting situations in which a meaningful measurement was difficult to make.

Completeness of the sample is bounded by two lines: (1) For each night sampling is at least 90 percent complete for events with u = 14.4 or brighter. (2) Descriptive parameters of flare light are not significantly biased by the recorder response (with a one second time constant) for events with $T_{0.5}$ greater than 0.08 minutes. Since no flares of so short a duration were recorded, the influence of instrumental response on estimates of peak light is assumed to be negligible.

A flare incidence relation giving the event rate for flares brighter than magnitude u, taking the form

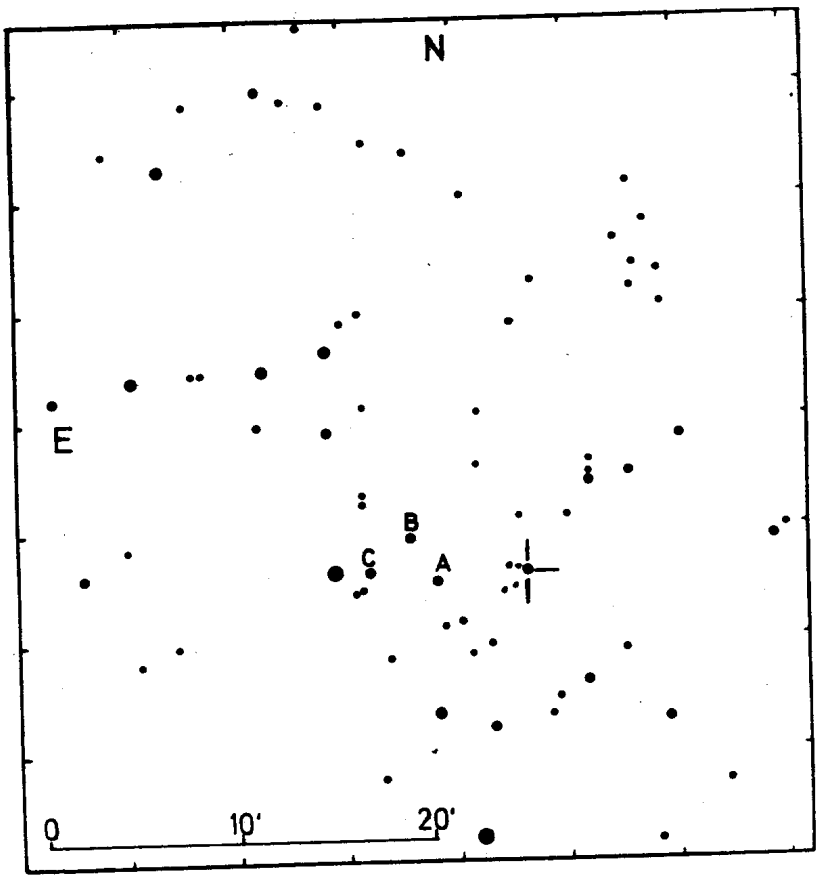
$$R(u) = \exp\left[a\,(u - u_o)\right] \quad \text{events hr}^{-1}$$

represents the observations well (see figure 2) above a 90 percent completeness level of $u_{lim} = 14.4$. The constants take the values $a = 0.78 \pm 0.12$ and $u_o = 14.69 \pm 0.15$.

Table 2. Flare Abstract, Proxima

Event U.T.	Air-mass	U_{peak}	$T_{0.5}$	$T_{0.1}$	τ_1	τ_2	τ_3	Notes
7 Feb. 1969	$7^h01^m.0$ - $9^h00^m.3$				3 events	T = $1^h.988$		
$8^h22^m.60$	1.24	13.58	0.15	0.68	+0.99	+0.8:		
8 23.40	1.24	13.91	.52	2.6:	c			
8 43.53	1.22	14.46	.37		-			
8 Feb. 1969	$7^h03^m.1$ - $9^h00^m.5$				1 event	T = $1^h.957$		
$8^h48^m.16$	1.21	15.05	0.13		-			
14 April 1969	$1^h52.6$ - $9^h41^m.4$				11 events	T = $7^h.813$		
$2^h10^m.87$	1.47	14.29	1.5		-0.27			
2 29.32	1.40	12.10	.13	1.52	+0.96	-0.08	-0.46	note 1
3 02.98	1.33	11.87	-	1.9:	-	-	-0.09:	note 2
3 54.51	1.25	13.18	.31	1.35	+0.49	+0.45	.0:	
4 57.85	1.18	13.75	.40		+0.12			
5 29.0	1.18	14.17	13.2	32:	-1.05			
5 31.13	1.18	12.89	.39	2.0	+0.36	0.0	-0.21	
5 45.33	1.18	14.20	.18		-0.09			
5 46.96	1.18	13.03	.45	1.45	+0.5, c	+0.23	-0.21:	
7 50.69	1.28	15.26	2.2		-			
9 14.3	1.46	15.58	2.2:		-			
15 April 1969	$0^h25^m.4$ - $3^h52^m.4$				3 events	T = $3^h.450$		
1^h02^m	1.70	14.34	4.		-			
1 22.5	1.60	12.72c	7.2	15.8	-0.68	-0.71	-0.82	note 3
3 01	1.32	15.02	11.5		-			
17 April 1969	$0^h57^m.6$ - $9^h18^m.5$				10 events	T = $8^h.348$		
$1^h09.65$	1.62	12.77	0.14	3.7	+0.86	-0.41	-0.41	
1 32.78	1.54	14.64	.18		-			
1 50.35	1.48	14.54	.5:		-			
1 54.98	1.46	14.37c	.6, c		-			note 4
2 55.83	1.32	12.73	.4	4.4	+0.26	+0.07	-0.55	
4 08.20	1.22	14.05	.58		+0.18			
5 14.29	1.18	14.93	.3		-			
6 43.61	1.18	14.31	.09		-			
6 53.86	1.22	14.77	.40		-			
7 05.68	1.23	13.27	.10	1.04, c	+1.36	+0.57		

Note 1 τ_4 = -0.99:
2 τ_4 = -0.67: "fast event," peak lost while seeking proper gain setting.
3 Three peaks
4 Double peak separated by 2.5 minutes in time.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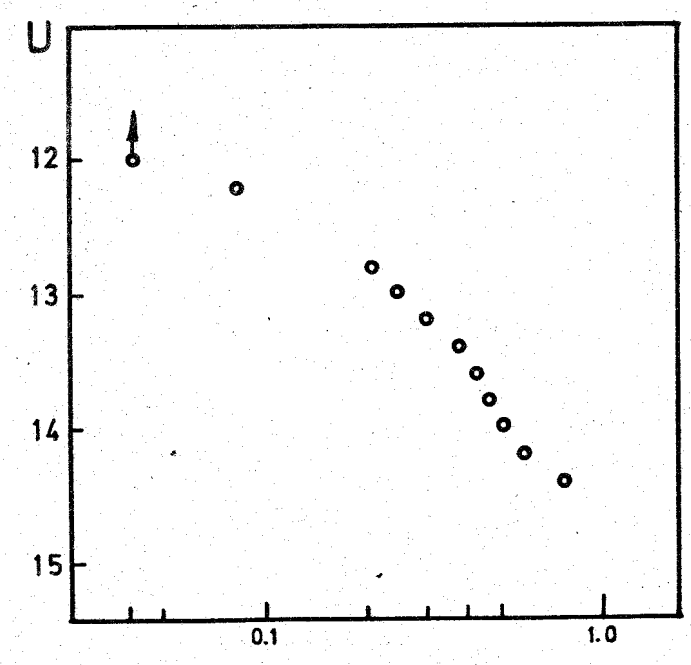

A direct comparison of the activity of Proxima Centauri with that of other flare stars of low luminosity is facilitated by a transformation of the flare activity parameter u_o to a scale of absolute magnitudes, $M_{u,o}$. If we assume that the constant "a" takes on a unique value for all stars (data presently available are not sufficient to reject this hypothesis), the value of $M_{u,o}$ serves as a comparative measure of flare activity: lower values denoting greater activity. Three stars of low luminosity for which measures of $M_{u,o}$ are available are Wolf 424A, B, UV Ceti, and Wolf 359, with $M_{u,o}$ = 17.8, 17.2 and 18.15 respectively. Activity of the binaries is assumed to be divided equally between components since the components are of practically equal luminosity. The value of $M_{u,o}$ for Proxima is 19.1, indicating a level of flare activity that is only moderate. It appears quite possible that

flare activity was more pronounced at the time of Shapley's observations, since the upper limit in flare activity proposed by Kunkel (1970) for stars of the luminosity of Proxima is about $M_{u,o} = 17$.

Cerro Tololo Inter-American Observatory+
1970 August 21

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