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OPTICAL OBSERVATIONS OF UV CETI FLARE STARS SIMULTANEOUS WITH RADIO COVERAGE

During January and February 1974, extensive radio observations of the flare stars, YZ CMi, AD Leo, Wolf 424AB, and CN Leo were obtained by Steven R. Spangler using the 1000 ft. radio telescope at Arecibo, Puerto. In this same period, simultaneous high-time-resolution optical coverage was provided at McDonald Observatory. A discussion of the flare events, observed in common at both stations, is given by Spangler and Moffett (1975). This report gives only the optical results obtained at McDonald. Since the optical coverage was incompleted, due to weather conditions, we urge other optical observers to communicate any data which they may have acquired during this observing interval.

INSTRUMENTATION

The optical observations were obtained with a high-speed-pulse-counting photometer attached to either the 91- or 76-cm reflector at McDonald Observatory. The basic instrument is described by Nather and Warner (1971).

Due to scheduling difficulties, several different photomultiplier tubes had to be used during the course of the program (RCA 1P21, RCA 4516, Amperex 56DVP, and a FW-130). The standard PMT used in the system is the 56 DVP, which is very similar to the others used except for the FW-130, which has an S-20 photocathode. This unfortunate circumstance means that the observations are not entirely homogeneous. Since the instrumental system employing the FW-130 is not well defined, certain flare parameters have been omitted for event detected using that system.

OBSERVATIONS

The reduction methods and notation used are described by Moffett (1974). The four flare stars were observed for a total of 102.47 hours, during which, 119 flares were detected.

Tables 1-4 give the coverage intervals together with the telescope and filter used in the monitoring. Tables 5-8 give the optical flare parameters for the flares detected on each star. The last column (Notes) states the photomultiplier in use at the time. Table 9 provides a summary of the observations. The flare frequency given is just a mean without consideration of flare amplitude, detection effects etc.

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References:

Nather,R.E., and Warner,B. 1971, M.N.R.A.S., 152, 209
Moffett,T.J. 1974, Ap.J.Suppl., 29, No. 273
Spangler,S.R., and Moffett,T.J. 1975, Ap.J.,(in press)

Table 1

Coverage of YZ Canis Minoris

Date (UT)	From(UT)	To(UT)	ΔT(s)	Tel. (cm)	Filter(s)
1974 January 15	03 08 01	03 33 28	1527	76	U
(2442062.5)	03 33 43	05 31 43	7080	76	U
1974 January 16	02 42 37	05 31 39	10142	76	U
(2442063.5)					
1974 January 17	02 38 11	05 31 09	10378	76	U
(2442064.5)					
1974 January 18	02 21 57	03 16 41	3284	76	C
(2442065.5)					
1974 January 20	02 12 08	02 28 32	984	76	U
(2442067.5)	02 34 04	03 54 40	4836	76	U
	03 56 18	05 05 52	4174	76	U
	05 07 01	05 30 25	1404	76	U

Table 1 (Continued)

1974 January 21	02 30 38	02 54 06	1408	76	C	
(2442068.5)	02 55 48	04 02 24	4176	76	U	
	04 05 31	05 29 33	5042	76	U	
1974 January 26	02 14 50	02 27 40	707	91	C	
(2442073.5)	03 00 30	04 17 30	4623	91	C	
	04 18 30	05 03 56	2726	91	C	
1974 January 28	02 47 22	03 44 32	3440	91	C	
(2442075.5)	03 46 10	03 51 10	306	91	C	
	03 52 00	05 12 10	4864	91	U	
1974 January 29	02 26 44	03 59 44	5592	91	U	
(2442076.5)	04 00 02	05 10 22	4284	91	U	
1974 January 30	02 51 45	05 34 05	9760	91	U	
(2442077.5)						
1974 January 31	02 09 15	03 45 55	5832	91	U	
(2442078.5)	04 08 08	05 16 08	4254	91	U	
1974 February 01	02 53 24	03 53 46	3622	91	C	
(2442079.5)	03 54 39	05 21 21	5202	91	C	
1974 February 16	01 45 20	02 31 00	2740	91	u	(S-20)
(2442094.5)	02 39 19	03 21 39	2540	91	u	(S-20)
1974 February 17	02 13 10	03 24 45	4295	91	v	(S-20)
(2442095.5)						
1974 February 19	01 52 08	03 15 48	5020	91	B	(S-20)
(2442097.5)						
1974 February 20	02 08 39	03 18 52	4213	91	B	(S-20)
(2442098.5)						
1974 February 22	01 51 02	03 00 06	4144	91	B	(S-20)
(2442100.5)						

Table 2

Coverage of CN Leo

1974 January 27	10 05 45	10 29 39	834	91	C
(2442074.5)	10 45 32	11 50 08	3876	91	C
1974 January 28	10 26 13	11 51 34	5121	91	C
(2442075.5)					
1974 January 30	10 05 51	11 01 08	3317	91	C
(2442077.5)	11 02 39	11 32 31	1792	91	C
1974 January 31	05 32 00	06 28 10	3374	91	C
(2442078.5)	06 31 41	07 42 11	4234	91	C

Table 3

Coverage of AD Leonis

Date (UT)	From (UT)	To (UT)	ΔT (s)	Tel. (cm)	Filter(s)
1974 January 15 (2442062.5)	06 03 02	08 22 58	8396	76	U
1974 January 16 (2442063.5)	05 39 57	08 31 31	10294	76	U
1974 January 17 (2442064.5)	05 38 14	08 42 02	11028	76	U
1974 January 18 (2442065.5)	08 05 17	08 31 39	1582	76	U
1974 January 20 (2442067.5)	05 35 50	08 27 20	10290	76	U
1974 January 21 (2442068.5)	05 38 38	07 41 12	7354	76	U
	07 41 56	08 27 22	2726	76	U
1974 January 26 (2442073.5)	05 12 58	05 58 18	2718	91	C
	06 02 07	06 37 07	2108	91	C
1974 January 28 (2442075.5)	05 25 00	05 46 10	1281	91	U
	06 01 45	06 10 15	515	91	U
1974 January 29 (2442076.5)	05 18 18	06 29 58	4336	91	U
	06 30 40	07 44 20	4464	91	U
1974 January 30 (2442077.5)	05 39 18	07 14 10.	5692	91	U
1974 February 01 (2442079.5)	05 25 11	07 39 11	8058	91	U
1974 February 16 (2442094.5)	03 29 00	04 32 15	3795	91	u (S-20)
	04 32 47	06 03 57	5470	91	u (S-20)
1974 February 17 (2442095.5)	03 33 07	05 15 46	6159	91	v (S-20)
	05 16 33	06 24 43	4090	91	v (S-20)
1974 February 19 (2442097.5)	03 23 21	05 02 15	5934	91	B (S-20)
	05 04 54	06 19 03	4449	91	B (S-20)
1974 February 20 (2442098.5)	03 24 24	05 04 34	6010	91	C (S-20)
	05 07 33	05 49 43	2530	91	C (S-20)
	05 50 22	06 14 04	1422	91	C (S-20)

Table 4

Coverage of Wolf 424 AB

Date (UT)	From (UT)	To (UT)	ΔT (s)	Tel. (cm)	Filter(s)
1974 January 16 (2442063.5)	09 21 09	11 05 39	6270	76	C
1974 January 17 (2442064.5)	08 55 29	09 56 35	3666	76	C
	09 57 15	11 07 44	4229	76	C
1974 January 18 (2442065.5)	08 38 02	11 00 53	8571	76	C
1974 January 20 (2442067.5)	08 33 11	09 26 10	3179	76	C
	09 27 26	11 16 44	6558	76	C
1974 January 21 (2442068.5)	08 33 09	09 04 17	1868	76	C
	09 04 23	09 36 18	1915	76	C
	09 36 56	10 20 22	2606	76	C
1974 January 29 (2442076.5)	08 10 07	08 47 47	2266	91	U
	08 48 11	09 49 11	3680	91	C
1974 January 30 (2442077.5)	07 56 44	09 09 44	4388	91	U
	09 12 11	10 00 31	2915	91	C
1974 January 31 (2442078.5)	07 48 34	10 01 54	7992	91	U
1974 February 01 (2442079.5)	07 51 36	09 59 16	7820	91	C
1974 February 16 (2442094.5)	06 27 23	06 44 41	1038	91	u (S-20)
	07 01 33	08 24 38	4985	91	u (S-20)
1974 February 17 (2442095.5)	06 40 27	07 42 11	3704	91	v (S-20)
	07 44 23	08 25 33	2470	91	v (S-20)
1974 February 19 (2442097.5)	06 30 07	08 16 17	6370	91	B (S-20)
1974 February 22 (2442100.5)	06 10 00	07 26 00	4560	91	B (S-20)
	07 28 56	08 02 39	2023	91	B (S-20)

Table 5

Flare Parameters for YZ CMi

Flare No.	HJD (MAX) 2440000.+	RISE (s)	DECAY (s)	F	I_{max}	σ/I_o	E.D. (s)	log E (ergs)	NOTES
1	2062.71737	30	406	U	1.5	.11	73.6	30.44	1P21, spike
2	2063.64372	15	158	U	0.6	.11	19.2	29.85	56DVP, spike, double peak
3	2063.66689	136	178	U	0.5	.11	11.4	29.63	56DVP
4	2063.68955	30	99	U	0.9	.11	24.8	29.96	56DVP, spike
5	2063.71990	125	354	U	0.6	.11	45.9	30.23	56DVP
6AP	2064.69071	36	198	U	0.5	.07	5.7	29.33	56DVP, spike
6BP	2064.69474	150	627	U	0.3	.07	36.9	30.14	56DVP, slow
6C	2064.70326	31	996	U	0.9	.07	114.7	30.63	56DVP
7A	2067.63097	128	284	U	0.9	.15	71.6	30.43	56DVP
7B	2067.64130	108	102	U	0.9	.15	73.6	30.44	56DVP, double peak
7C	2067.64401	72	166	U	0.6	.15	31.4	30.07	56DVP
7D	2067.65100	278	266	U	0.6	.15	76.8	30.46	56DVP, slow
8A	2067.67554	12	20	U	1.6	.08	12.2	29.66	56DVP, spike
8B	2067.68800	447	273	U	0.4	.08	176.3	30.82	56DVP, slow
8C	2067.70545	391	213	U	0.5	.08	56.2	30.32	56DVP, slow
9	2068.63998	14	110	U	0.6	.09	9.1	29.53	56DVP, spike
10A	2068.65926	8	70	U	0.9	.09	14.2	29.72	56DVP, spike
10B	2068.66055	42	498	U	0.8	.09	53.4	30.30	56DVP
10C	2068.67292	32	250	U	0.8	.09	60.8	30.35	56DVP, multi-peak?
11AP	2068.67844	18	142	U	0.4	.08	15.9	29.77	56DVP
11B	2068.68587	120	440	U	1.8	.08	261.4	30.99	56DVP, multi-peak?
11C	2068.70205	12	144	U	2.4	.08	63.1	30.37	56DVP, spike
11D	2068.71135	12	92	U	2.1	.08	27.9	30.02	56DVP, spike

Table 5 (Continued)

11E	2068.71552	10	16	U	0.6	.08	4.7	29.24	56DVP, spike
11F	2068.71930	51	175	U	0.4	.08	27.2	30.01	56DVP
12	2073.66493	140	93	C	0.1	.02	5.1	30.55	RCA4516
13A	2076.61319	--	1220	U	0.5	.06	>175.2	> 30.81	RCA4516, missed start
13B	2076.62752	18	738	U	0.5	.06	49.4	30.26	RCA4516
13C	2076.63768	14	110	U	0.3	.06	6.4	29.38	RCA4516
14A	2077.63530	77	649	U	0.3	.07	49.3	30.26	RCA4516
14B	2077.64319	33	745	U	0.6	.07	43.8	30.21	RCA4516, spike
14C	2077.65610	74	1496	U	0.3	.07	87.0	30.51	RCA4516
14D	2077.67441	60	212	U	0.3	.07	16.9	29.80	RCA4516
14E	2077.69200	52	960	U	0.3	.07	72.5	30.43	RCA4516
14F	2077.70334	20	938	U	0.7	.07	48.0	30.25	RCA4516, spike
14G	2077.72501	66	260	U	0.7	.07	33.0	30.9	RCA 4516, multi-peak
15AP	2078.68731	42	318	U	0.3	.06	27.8	30.01	56DVP
15B	2078.69---	--	---	U	---	.06	>15.2	>29.75	56DVP, missed start
15C	2078.69400	24	886	U	0.3	.06	72.1	30.43	56DVP, slow

Table 6

Flare Parameters for CN Leo

FLARE No.	HJD (MAX) 2440000.+	RISE (s)	DECAY (s)	F	I_{MAX}	σ/I_o	E.D. (s)	Log E (ergs)	NOTES
1	2074.96859	6	19	C	0.9	.06	3.2	28.57	RCA4516, spike
2AP	2075.95064	6	23	C	0.6	.06	3.4	28.60	RCA4516, spike
2BP	2075.95855	22	1213	C	1.5	.06	118.4	30.14	RCA4516
2CP	2075.97280	9	207	C	1.9	.06	---	----	RCA4516, spike
2D	2075.97526	5	---	C	3.1	.06	---	----	RCA4516
3AP	2077.93576	23	254	C	1.8	.07	35.6	29.62	RCA4516, spike
3BP	2077.94159	5	99	C	0.4	.07	6.5	28.88	RCA4516
3CP	2077.95037	15	176	C	0.4	.07	18.0	29.32	RCA4516
3D	2077.95689	14	607	C	10.4	.07	555.9	30.81	RCA4516, double spike
4	2077.96627	--	495	C	0.6	.07	>74.7	>29.94	RCA4516, missed start
5A	2078.80112	11	73	C	0.4	.07	8.0	28.97	56DVP
5B	2078.80436	79	194	C	0.3	.07	10.6	29.09	56DVP
5C	2078.81008	7	68	C	0.2	.07	1.7	28.29	56DVP

Table 7

Flare Parameters for AD Leo

FLARE No.	HJD (MAX) 2440000.+	RISE (s)	DECAY (s)	F	I_{MAX}	σ/I_0	E.D. (s)	Log E (ergs)	NOTES
1AP	2063.76555	220	855	U	0.1	.03	51.2	30.83	56DVP, slow
1B	2063.78088	33	405	U	0.5	.03	24.6	30.51	56DVP, spike
1C	2063.78652	83	334	U	0.1	.03	15.6	30.31	56DVP, slow
1D	2063.79645	124	531	U	0.3	.03	67.3	30.95	56DVP, slow
2	2063.83005	65	169	U	0.1	.03	6.6	29.94	56DVP, slow
3	2063.84715	8	178	U	0.2	.03	9.4	30.09	56DVP, flat top
4	2064.74307	214	606	U	0.2	.03	40.7	30.73	56DVP, slow
5AP	2064.78240	78	194	U	0.1	.03	7.2	29.98	56DVP, slow
5B	2064.78529	43	649	U	0.3	.03	29.7	30.59	56DVP, double peak
5CP	2064.78529	52	259	U	0.1	.03	8.0	30.02	56DVP, complex
5D	2064.82969	55	374	U	0.3	.03	19.2	30.40	56DVP, flat top
5E	2064.84529	42	320	U	0.2	.03	13.4	30.25	56DVP
5F	2064.85530	544	783	U	0.2	.03	91.0	31.08	56DVP, slow complex
6	2065.84356	14	126	U	0.1	.03	2.8	29.57	56DVP, spike
7AP	2067.80047	46	46	U	0.1	.04	2.5	29.52	56DVP
7B	2067.82239	196	484	U	1.6	.04	123.4	31.21	56DVP, double
7C	2067.83025	194	292	U	0.1	.04	26.9	30.55	56DVP, slow
8	2068.75297	6	32	U	0.1	.03	2.5	29.52	56DVP
9	2068.80027	280	1472	U	0.5	.03	122.6	31.21	56DVP, complex
10	2068.83698	58	436	U	0.1	.03	6.9	29.96	56DVP
11A	2076.79435	73	472	U	0.1	.02	16.0	30.32	RCA4516, slow
11B	2076.81294	618	1274	U	0.3	.02	86.0	31.06	RCA4516, complex slow

Table 7 (Continued)

12A	2077.75529	12	1172	U	0.2	.02	22.3	30.47	RCA4516, complex
12B	2077.77330	322	1030	U	0.2	.02	28.3	30.47	RCA4516, multi-peak
13AP	2079.75807	23	216	U	0.2	.02	10.5	30.14	56DVP
13BP	2079.76897	188	1212	U	0.3	.02	41.2	30.74	56DVP
13C	2079.80221	234	1458	U	1.9	.02	507.8	31.83	56DVP, complex, 2 major peaks
14AP	2094.70272	116	476	u	4.1	--	---	----	S-20 PMT
14B	2094.71091	232	2756	u	139.8	--	---	----	S-20 PMT
14C	2094.74327	36	1392	u	5.0	--	---	----	S-20 PMT
15AP	2098.67815	50	1050	C	0.3	--	---	----	S-20 PMT
15B	2098.69348	260	2040	C	1.7	--	---	----	S-20 PMT

Table 8

Flare Parameters for Wolf 424AB

FLARE No.	HJD (MAX) 2440000.+	RISE (s)	DECAY (s)	F	I_{MAX}	σ/I_o	E.D. (s)	Log E (ergs)	NOTES
1	2063.89781	9	198	C	0.2	.02	7.2	29.90	56DVP, double spike
2	2063.95943	17	206	C	0.5	.03	11.8	30.11	56DVP, spike
3AP	2064.88545	6	47	C	0.1	.03	1.0	29.04	56DVP, very small
3B	2064.88741	35	137	C	0.2	.03	6.2	29.83	56DVP, multi-peaked?
4	2064.92707	14	253	C	0.2	.03	14.9	30.21	56DVP, flat top
5	2065.91720	4	242	C	0.2	.03	7.3	29.90	56DVP, double peaked?
6A	2067.87823	3	363	C	0.3	.04	12.6	30.14	56DVP, spike
6B	2067.88680	25	35	C	0.2	.04	2.1	29.36	56DVP
7	2067.93552	10	136	C	0.7	.04	9.4	30.01	56DVP, spike
8	2067.96048	11	14	C	0.2	.04	0.6	28.82	56DVP
9	2068.87063	7	147	C	0.3	.03	4.5	29.69	56DVP, spike
10	2076.86162	54	699	U	1.1	.22	86.2	29.55	RCA4516
11	2076.88768	11	287	C	0.1	.02	5.3	29.77	RCA4516
12	2076.90780	156	156	C	0.1	.02	4.7	29.71	RCA4516, slow
13AP	2077.85407	22	148	U	0.7	.18	37.6	29.19	RCA4516
13B	2077.85671	80	704	U	2.7	.18	347.1	30.16	RCA4516, multi-peak
13C	2077.86504	16	604	U	2.3	.18	109.5	29.66	RCA4516, spike
13D	2077.87296	80	118	U	1.3	.18	17.7	28.87	RCA4516, pure spike
13E	2077.87738	12	374	U	2.0	.18	54.4	29.35	RCA4516, double spike
14	2077.89086	18	56	C	0.1	.03	1.5	29.22	RCA4516, max not well defined
15	2077.89606	5	82	C	0.1	.03	1.4	29.19	RCA4516
16	2077.89951	18	43	C	0.1	.03	1.6	29.25	RCA4516

17	2077.91029	8	14	C	0.2	.03	0.5	28.74	RCA4516, spike
18	2078.83912	22	422	U	3.7	.20	148.9	29.79	56DVP, complex
19A	2078.86473	86	130	U	4.7	.20	85.8	29.55	56DVP, complex spike
19B	2078.86769	16	486	U	3.1	.20	177.9	29.87	56DVP, multi-peak spike
19C	2078.90414	5	249	U	3.4	.20	152.3	29.80	56DVP, multi-peak spike
20	2079.84103	8	56	C	0.2	.02	1.3	29.16	56DVP, spike
21	2079.88198	34	60	C	0.1	.02	2.1	29.36	56DVP
22	2079.90971	10	794	C	0.2	.02	16.0	30.25	56DVP, spike
23	2100.79879	8	10	B	0.1	--	---	---	S-20 PMT, spike
24	2100.79939	2	18	B	0.2	--	---	---	S-20 PMT, spike
25	2100.81671	-	--	B	0.1	--	---	---	S-20 PMT, spike
26	2100.83659	-	--	B	0.1	--	---	---	S-20 PMT, spike
27	2100.83886	-	--	B	0.1	--	---	---	S-20 PMT, spike

Table 9

Summary

STAR	COVERAGE (hr)	No. OF FLARES	FLARES/HR (1/hr)
YZ CMi	36.83	39	1.06
AD Leo	33.53	32	0.95
Wolf 424AB	25.85	35	1.35
CN Leo	6.26	13	2.08
TOTAL	102.47	119	1.16