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AN INCREASE IN STELLAR ACTIVITY IN THE ECLIPSING BINARY CM Dra

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CM Draconis is a system of interest for many reasons. It is one of the few known M-dwarf eclipsing binary systems. Although these types of systems may form a large percentage of stellar systems in our galaxy, their low luminosity limits their detection to nearby systems. Thus, study of these few systems may provide insight into an important subset of the stellar population. As a UV-Cet type system, CM Dra is prone to violent flare activity. UV-Cet stars can produce flares 10-1000 times as energetic as solar flares (Shakhovskaya, 1989), and can occur at a rate greater than 2 flares/hour (Lacy et al., 1976). Presented in this paper are six such flare events, observed at Appalachian State University's Dark Sky Observatory in May 2006.

Despite the presence of strong flares, which emit large amounts of UV radiation, M-dwarf stars are suitable hosts for life supporting planets (Heath et al., 1999). In the case of CM Dra, its low luminosity and its nearly edge on inclination make it a suitable target for ground based planet transit searches as shown by the efforts of the TEP (Transits of Extrasolar Planets) network (Deeg et al., 1998). While the TEP group initially reported several transit events, follow-up observations failed to confirm the events as planet transits.

A transiting planet search program is currently underway at Appalachian State University. To follow up the results of the TEP network, we decided to include CM Dra in our target list. To date, we have amassed 105 hours of observation time on the system. These observations were obtained using the 32-inch main telescope at Appalachian's Dark Sky Observatory, located 20 miles northeast of Boone, NC, at an elevation of 1km. The 32-inch Richey-Chretien is equipped with a Photometrics CH250 CCD camera with a Tektronix 1024-square chip, thinned and thermoelectrically cooled. All data were taken in the R-band at 120 second exposures, and were reduced using MIRA 6 and comparison and check stars as shown in Figure 1 (C: V=$12\overset{m}{.}7$, $B-V$=$0\overset{m}{.}54$; K1: V=$13\overset{m}{.}1$, $B-V$=$0\overset{m}{.}52$; K2: V=$13\overset{m}{.}7$, $B-V$=$0\overset{m}{.}66$). These are a subset of the standard stars used in the TEP project (Deeg et al., 1998).

Over the course of three nights of observations in May 2006, six flares in CM Dra were observed: one on JD2453878 with a magnitude change of 0.23 and a duration of one hour, three on JD2453879 with a magnitude change of 0.04, 0.08, and 0.09 respectively, with the whole event lasting well over two hours, and two on JD2453883 with magnitude changes of 0.02, and both events lasting over 30 minutes. The fact that all of the flares were observed in the R-band speaks to the highly energetic nature of these flares, as flares are most readily observed in the U, B, and V, respectively (Oláh et al., 1991).

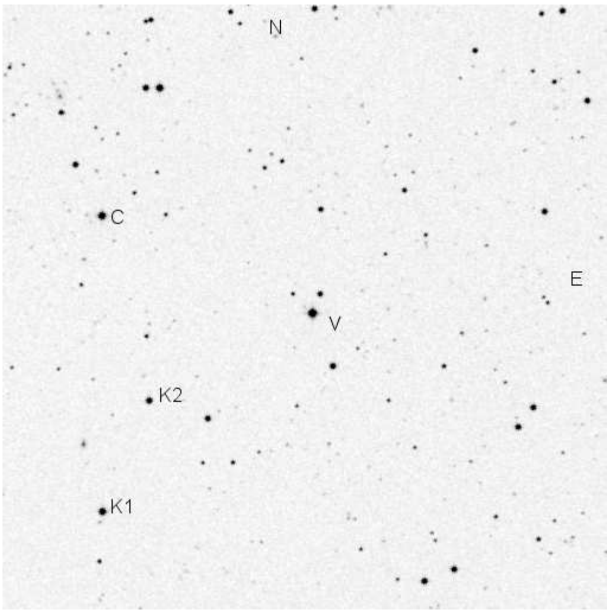

Figure 1. Finding chart for CM Dra. (13 arc-min square.)

All six events display the classic shape of a stellar impulsive flare, with the maximum brightening occurring during a single exposure, and each subsequent point tailing off gradually back towards the quiescent magnitude of the system. The three flares on JD2453879 are a special case because they occurred in such proximity chronologically to each other. The second flare event began before the first subsided, and likewise with the third. Also, each successive flare was more powerful than the proceeding. These flares are an instance of sympathetic flaring. All of the flares are plotted by night in Figure 2.

Table 1. Observation Log

Obs. Dates	Obs. Period	Airmass	Phase
May 2006			
22-23	2453878.62 - 2453878.88	1.27 - 1.25	0.336 - 0.543
23-24	2453879.61 - 2453879.88	1.26 - 1.26	0.124 - 0.330
27-28	2453883.64 - 2453883.88	1.18 - 1.29	0.294 - 0.483

Phase determined from P = 1.2683897 (Lacy, 1977) and E = 53478.6467 (Smith et al., 2007)

Table 2. Observed Flare Events

Flare	Date (H.J.D.)	Phase	Variation (mags in R)	Duration (hrs)
1	2453878.848	0.519	0.23	1.00
2	2453879.784	0.257	0.04	$\geq$ 2.25
3	2453879.808	0.276	0.08	$\geq$ 2.25
4	2453879.836	0.298	0.09	$\geq$ 2.25
5	2453883.702	0.346	0.02	0.57
6	2453883.853	0.465	0.02	$\geq$ 0.67

Phase determined from P = 1.2683897 (Lacy, 1977) and Epoch = 53478.6467 (Smith et al., 2007)

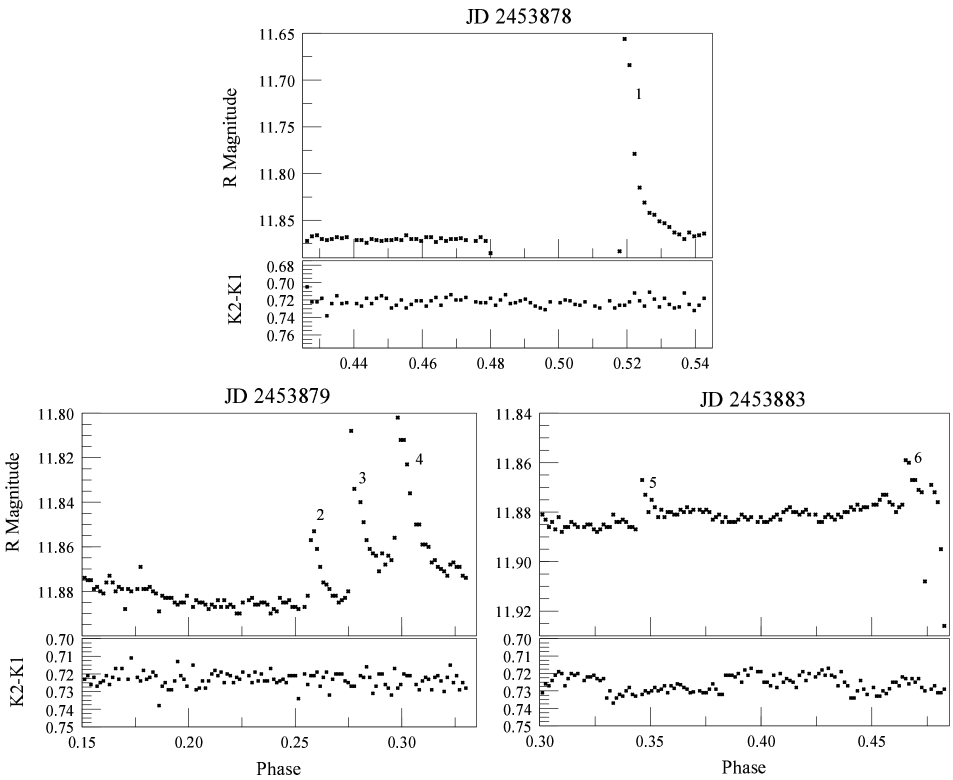

Figure 2. Six flare events were observed in CM Dra over three nights in May 2006.

Flares on CM Dra have been recorded before (Eggen et al., 1967; Lacy, 1977; Metcalfe et al., 1996; Kim et al., 1997; and Kozhevnikova et al., 2004), with magnitude increases ranging from 0.02 to 0.7 mag (in different filters) and most lasting on the order of one hour. Although, as Lacy (1977) points out, the rate of flaring observed from CM Dra is much lower than other Population I, UV-Cet type flare stars. From this, he hypothesized that CM Dra is actually an evolved Population II star system. Since then there has been little to refute this hypotheses. Observed flare rates are still much lower than would be expected from a Pop. I system, which could exceed two flares per hour. Lacy (1997) estimated a rate of less than 0.05 flares/hour, Metcalfe et al. (1996) estimated a rate of 0.02 flares/hour, Kim et al. (1997) estimated less than 0.04 flares/ hour, and Kozhevnikova et al. estimated 0.026 flares/hour.

From these new data, we are estimating a rate of 0.057 flares/hour, higher than any previous determination, but still well below the expected rate of a Pop. I UV-Cet type flare star.

However, even though our overall flare rate is fairly low, all six observed flares were observed during one week, giving an estimated localized rate of 0.33 flares/hour during that span. The previous observed flare events occurred apparently randomly in the phase of the system, as well as randomly in time. Not only did the flare observations presented here occur in a short time span, they also occupy a localized section of the system's phase. All of the flares occurred shortly before or after the secondary minimum. In fact, flare 1 began before a secondary eclipse ended, and flare 6 was still occurring when an eclipse began. With the system inclination nearly 90 degrees, it is very likely that flare 1 and 6 erupted from the secondary component. It is also possible that all six flares stemmed from a very large region of activity on the secondary star, one that covered a quarter of the star's surface in longitude.

On our own sun, we observe an eleven year cycle of solar activity, with flares and sunspots observed more often near the peak of the cycle. These new data may suggest just such a cycle on CM Dra, with such high activity in a short period of time. Of course, further observation is needed to detect any periodicity in flare activity. We can use these data, however, as direct evidence of a localized period of time of high surface activity, including spots and flares, in CM Dra.

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