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VARIABILITY OF HD 137147 (COMPARISON STAR OF UCrb)  
AND "A FLARE" OF HD 137050

Photoelectric light curves of U Cr B have been published by Wood (1958), Catalano et al. (1966), and Svolopoulos and Kapranidis (1972). These light curves show larger-than-normal scatter, which varies from  $\pm 0.05$  mag to  $\pm 0.1$  mag. All observers used comparison star HD 137147 (= BD + 32<sup>o</sup>2578, Sp Tp F0). We have monitored this star against HD 136654 (= BD + 31<sup>o</sup>2724, Sp Tp F8V (Buscombe 1977)) and HD 137050 (= BD + 32<sup>o</sup>2577, Sp Tp F8). We report a "flare" on HD 137050 and light variation of the comparison star HD 137147. All evidence suggests that HD 136654 is truly constant in brightness, and we refer to it below as the "reference" star.

Observations were obtained on small portions of six nights at Kitt Peak National Observatory between UT May 19 and May 26, 1980, using the No. 4 0.4M and No. 2 0.9M reflectors, and on larger portions of six nights at Prairie Observatory between May 5 and June 30, 1980, using the 1.0M reflector. Single channel pulse-counting photometers with RCA 031034A-02 photomultiplier tubes were used for all observations. Five color uvby  $I_K$  photometry was obtained by repeated cycling among the three stars and sky. Standard stars were observed on three nights at KPNO and two nights at PO to determine transformation and extinction coefficients. Differential magnitudes (relative to the reference star) were corrected for differential extinction and transformed to the standard Strömgen-Crawford and Kron systems; yellow magnitudes were converted to Johnson V.

## a) "FLARE" OF HD 137050

A slow, low-amplitude flare was observed on HD 137050 on May 21 1980 at KPNO with the No. 4 0.4M reflector. The night was photometric, and the mean error per differential measurement, HD 137147-reference, was  $\sim 0.006$  mag. Sky

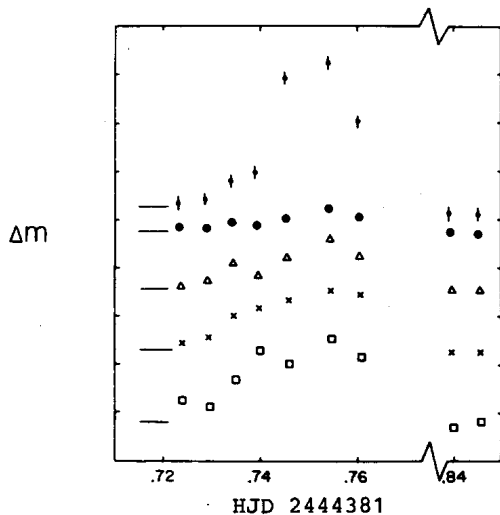


Figure 1: Light curve of the flare in HD 137050. Top to bottom, infrared to ultraviolet. Curves have been shifted vertically for clarity;  $\Delta m = \text{HD 137050} - \text{reference}$ , and steps are 0.1 mag. Quiescent light levels are indicated by horizontal lines. Mean errors are shown on the I - curve, and are somewhat smaller in other colors.

counts were uniformly low and the flare event, shown in Figure 1, was undoubtedly real. The event was not recognized at the telescope and observations were stopped during light decline; a brief check two hours later showed the star at quiescent light level. This was the only flare-like event observed in 16.4 hours of monitoring on 12 nights. On the other 11 nights, HD 137050 was constant in all colors to  $\lesssim 0.005$  mag (Figure 2), except on June 26 and 28 when a slow variation  $\sim 0.02$  to  $0.03$  mag was noted in v and u. Quiescent levels are noted in Figure 1. Classical flare stars are typically dMe stars, though a few cases of unusual flare-like activity are known in B and A stars, (Kunkel 1975). It is of interest to inquire how similar the HD 137050 flare was to the UV Ceti phenomenon.

The reference star was tied to the standard systems on three photometric nights at KPNO, yielding:  $V = 6.920 \pm 0.007$  (m.e.),  $(b-y) = 0.314 \pm 0.002$ ,  $m_1 = 0.182 \pm 0.002$ ,  $c_1 = 0.426 \pm 0.011$ ,  $(u-b) = 1.418 \pm 0.010$ ,  $(V-I_K) = 0.37 \pm 0.02$ . From the mean quiescent  $\Delta mag$ , we find for HD 137050:  $V = 8.644$ ,  $(b-y) = 0.336$ ,  $m_1 = 0.186$ ,  $c_1 = 0.348$ ,  $(u-b) = 1.392$ , and  $(V-I)_K = 0.42$ , with mean errors equal to the reference star values. All indices for HD 137050 are consistent with unreddened spectral class F8. An M dwarf companion could be present without changing these colors significantly, and could flare intensely enough to give the observed flare amplitude. However,  $T_{0.5}$ , the flare duration at half-peak light, appears to be  $\gtrsim 30$  min, assuming that our poor time resolution has not lowered the observed peak significantly. Typical UV Ceti-type flare durations have mean values  $\lesssim 1$  min, and range from fractions of a minute to  $\sim 10$  minutes in rare cases (Kunkel 1973). Recently, though, Contadakis et al. (1980) observed a flare of EV Lac with  $T_{0.5} \sim 30$  min. It does seem likely that the flare was associated with the F8 star. If the M star relation between increasing flare duration and luminosity (Kunkel 1975) can be extrapolated to F8, this association becomes still more probable. Observed flare amplitudes are:  $u$ , 0.18;  $v$ , 0.11;  $b$ , 0.10;  $V$ , 0.05;  $I_K$ , 0.30 mag, giving rather uncertain excess flare light colors  $(b-y) \approx -0.5 \pm 0.2$  and  $(u-b) \approx +0.8 \pm 0.1$ . These colors translate roughly to  $(B-V) \approx -0.9 \pm 0.4$  and  $(U-B) \approx -0.5 \pm 0.1$ , and place the flare somewhat to the left of the UV Ceti region on the color-color plot of Cristaldi and Rodonò (1975). It is uncertain how valid the intermediate- to broad-band transformation is, given the probable emission-line nature of the spectrum. Peak flare luminosity  $\approx 4 \times 10^{32}$  erg sec<sup>-1</sup>, which is near the maximum radiation rate found by Cristaldi and Rodonò for UV Ceti flares. The total energy radiated by the event  $\approx 7 \times 10^{35}$  erg. By the few criteria described here, it seems possible that this flare did occur on the F8 star, and that its properties roughly fit extrapolations from the UV Ceti region.

## b) U Cr B COMPARISON STAR HD 137147

Except for the flare and for small violet and ultraviolet variations noted above, HD 137050 was constant relative to the reference state on all nights in all colors. Visual differential magnitudes are shown in Figure 2.

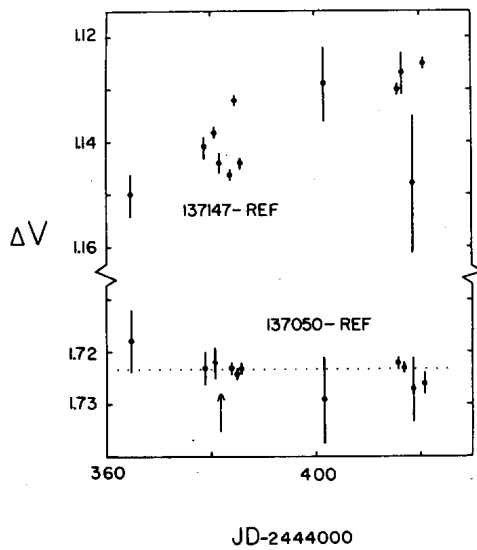


Figure 2: Differential visual magnitudes for U Cr B comparison star (above) and flare star (below). Vertical arrow marks the time of the flare. Nightly mean errors are shown.

Similar data for HD 137147 show a secular brightening of  $\sim 0.025$  mag over the 56-day interval, on which smaller, more rapid, fluctuations are superimposed. The secular brightening ranges from  $\sim 0.01$  mag in the ultraviolet to  $\sim 0.03$  mag in the near infrared. Since the full variation in HD 137147 has probably not been observed, it is possible that most of the scatter in published light curves of U Cr B originated in comparison star variability.

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