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Photoelectric photometry of six cataclysmic variable stars

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Summary. — Photoelectric photometry has been obtained for six stars identified as cataclysmic variable star candidates by Green *et al.* (1982). All six stars studied, PG 0244 + 104, PG 0834 + 488, PG 1550 + 131, PG 1550+ 191, PG 1717 + 413, and PG 2240 + 193 were confirmed to be cataclysmic variable stars. The optical variations of all six stars are discussed.

Key words : variable stars — photometry.

1. Introduction.

Green *et al.* (1982) have published a list of twenty-two cataclysmic star candidates selected from the Palomar-Green survey which contains over 2000 blue stellar objects that exibit *U-B* color excesses bluer than − 0.4 mag. This survey is complete to a *B* magnitude limit of approximately 16.2. All of the objects in this list were selected based on the identification of the presence of emission lines in the spectra of each candidate object. The purpose of the present paper is to report on the results of a photometric study of six of the stars selected from this list of cataclysmic variable star candidates. The stars which have been observed are listed in table I. Column one contains the star's identification, columns two and three contain the star's right ascension (1950.0) and declination (1950.0), and columns four, five, and six contain typical *V* magnitudes, *B-V* and *U-B* colors respectively.

2. Observations.

The photometric observations of all the variable stars reported here were obtained using either the No. 2 0.9 meter telescope or the 1.3 meter telescope at Kitt Peak National Observatory. A standard *UBV* filter set was used with the automated filter photometer (AFP) equipped with a 1P21 photomultiplier for the observations obtained with the 0.9 meter telescope. The Mark 2 computer photometer equipped with a 1P21 photomultiplier and standard *UBV* filters was used for the observations made with the 1.3 meter telescope. The extinction was determined for each night and the transformation to the standard *UBV* system was made using the standard stars of Landolt (1973).

3. Discussion.

The observations of each of the six stars are discussed individually in detail in the following sections :

PG 0244 + 104. — PG 0244 + 104 was included among the list of cataclysmic star candidates which were found to exhibit high-excitation-emission spectra. Photometry of PG 0244 + 104 was obtained on the nights of 1983 December 6, 7, and 8. The results of those observations are displayed in figures 1, 2, and 3 respectively. Erratic optical variations are seen to be present down to the limiting time resolution of approximately two minutes in all three bands (*UBV*). Typically the amplitude of these variations are ~ 0.2 mag (e.g. Fig. 1 and 2). However the amplitude of the variations are significantly greater on the night of 1983 December 8 during which the amplitude ~ 0.4 mag. The *V* magnitude for PG 0244 + 104 was approximately 15.2 with $B\text{-}V = 0.2$ and $U\text{-}B = -0.7$ and were essentially constant on a night-to-night basis for the observations reported for all three nights. The short-term variations reported for this object are consistent with those earlier reported for this object

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by Warner (1983). However, the B magnitude of 15.4 which we observed for this object is significantly fainter than $B = 14.7$ reported by Warner. Our value is somewhat brighter than the value $B \simeq 15.8$ quoted by Green *et al.* (1982). This indicates that there are long term variations which remain to be investigated in order to have a better understanding of the nature of this system.

PG 0834 + 488. — PG 0834 + 488 was identified as a cataclysmic star candidate having a high-excitation-spectrum. Photometric observations of this star have been obtained on the night of 1983 December 6 and are shown in figure 4. Small amplitude rapid variations were observed in all three bands (*UBV*) with an amplitude of approximately 0.2 mag. The mean B-magnitude observed for this object of approximately 14.75 is only slightly brighter than the B-magnitude reported by Green *et al.* (1982) of 14.9 and thus offers no evidence for long-term large-amplitude variations. Additional observations are necessary in order to confirm this last conclusion. The mean (B-V) and (U-B) colors were 0.1 and -0.7 respectively, and they exhibited no large scale variations which were correlated with the short-term flickering for this object.

PG 1550 + 131. — The spectrum of PG 1550 + 131 was found to be similar to that detected for U Gem-like objects by Green *et al.* (1982). Based on this comment on the spectrum of PG 1550 + 131, we have obtained photometry for this star. The observations obtained for PG 1550 + 131 on the night of 1983 June 9 are presented in figure 5. Variations of approximately 0.6 magnitudes are observed in the V band. During the one and one-half hours this star was observed, a rapid decline in brightness of approximately 0.6 magnitudes was followed by a modest recovery of approximately 0.4 magnitudes. Variations of ~ 0.2 mag are common. PG 1550 + 131 has an approximate mean B-$V = +-0.2$, but there are significant color variations associated with the brightness variations such that the B-V colors become considerably bluer when the object fades in brightness. The mean U-B colors are approximately -1.2. No large-scale color variations in (U-B) were observed to accompany the brightness variations. The B magnitude of ~ 16.6 is significantly fainter than that reported by Green *et al.* of 16.0, and this suggests that long term large amplitude variations may also be present.

PG 1550 + 191. — PG 1550 + 191 has earlier been identified as an AM Herculis-type binary system by Liebert *et al.* (1982). They established an orbital period for this star of 113.56 minutes defined by variations in the linear and circular polarizations. These authors reported photometry of this system for which $V = 15.0$, B-$V = +0.3$, and U-$B = -1.0$ at maximum and $V = 15.8$, B-$V = -0.05$, and U-$B = -1.3$ at minimum light.

We have observed PG 1553 + 191 on 1982 April 25 and 28, and the results are shown in figures 6 and 7 respectively. On both nights we have observed the star for more than one cycle and have confirmed the 113-minute period reported by Liebert *et al.* The maximum brightness observed in the V-band is near 15.0 mag but varies by up to 0.15 mag from one maximum to the next. *UBV* photometry was obtained only on the night of 1982 April 25. We obtained B-$V = 0.3$ and U-$B = -0.90$ at maximum brightness and B-$V = -0.25$ and U-$B = -1.2$ at minimum brightness in reasonable agreement with the earlier results reported by Liebert *et al.*

On the night of 1982 April 28, PG 1550 + 191 was monitored solely in the V-band. Short-term flickering was observed with an amplitude ~ 0.10 mag down to the limiting time resolution of the observations (~ 30 seconds). This short-term flickering is present throughout the cycle but appears to be of slightly larger amplitude near minimum light which is in agreement with the earlier observations of Liebert *et al.*

PG 1717 + 413. — PG 1717 + 413 exhibits a high excitation emission spectrum similar to that found for PG 0244 + 104 (Green *et al.*, 1982). The optical variations observed for this star on 1983 June 10 (Fig. 8) are also similar to those observed for PG 0244 + 104. Low amplitude short-term variations have been detected in all three bands (*UBV*) with an amplitude of ~ 0.2 magnitudes. No significant variations in the B-$V = 0.0$ or U-$B = -0.85$ colors were correlated with the brightness fluctuations. The approximate B magnitude of 14.05 mag is in good agreement with that reported by Green *et al.* (1982) of 13.9 for PG 1717 + 413.

PG 2240 + 193. — The spectrum of PG 2240 + 193 has been characterized as showing both emission and absorption features in the same spectra ; i.e. the Balmer absorption decrements are suggestive of emission-line filling, and Hα is strong in emission. Photometry of PG 2240 + 193 was obtained on the nights of 1983 June 11 and 13 and is shown in figures 9 and 10 respectively. Short-term optical variations were observed to be present on both nights with a maximum amplitude in the V-band of 0.5 mag. Significantly lower amplitude variations were detected in the B and U bands. The star, on the average, is approximately 0.1 mag brighter on the 1983 June 13 than on 1983 June 11. The observed B magnitude of 15.85 is in good agreement with the value reported by Green *et al.* (1982). The (B-V) ~ -0.1 varies significantly as the star's brightness fluctuates, but only mild variations of (U-B) ~ -0.7 are observed.

4. Summary.

All six stars which have been observed in this program have been found to exhibit short-term optical variations which are a characteristic of cataclysmic variable stars. Therefore we can confirm that these six stars which are included in the list of cataclysmic variable star candidates (Green *et al.*, 1982) are cataclysmic variable stars. The stars PG 0834 + 488, PG 1717 + 413, and PG 2240 + 193 all exhibit low amplitude flickering but show no evidence of large amplitude, long-term changes in brightness. PG 0244 + 104 exhibits both short-term low amplitude flickering as well as long term variations of in excess of 1.0 mag. PG 1550 + 131 exhibited large amplitude, short-term variations of more than 0.5 mag. Long-term,

large amplitude variations were not detected but cannot be ruled out by the present observations. PG 1550 + 191, a previously identified AM Herculis binary star, was observed and the short term flickering and 113-minute period in the optical variation of its brightness was confirmed.

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LIEBERT, J., STOCKMAN, H. S., WILLIAMS, R. E., TAPIA, S., GREEN, JR. F., RAUTENKRANZ, D., FERGUSON, D. H., SZKODY, P. : 1982, *Astrophys. J.* **256,** 594.
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TABLE I. — *cataclysmic variable stars observed.*

Star I. D.	R. A. (1950) h m s	DEC (1950) ° ′ ″	V	B-V	U-B
PG 0244 +104	02 44 54.5	+10 23 14	15.2	0.2	-0.7
PG 0834 +488	08 34 48.5	+48 48 37	14.8	0.1	-0.7
PG 1550 +131	15 50 35.8	+13 03 35	16.8	-0.2	-1.2
PG 1550 +191	15 50 33.1	+19 05 18	15.4	-0.2	-1.1
PG 1717 +413	17 17 01.0	+41 18 56	14.0	0.0	-0.8
PG 2240 +193	22 40 01.1	+19 16 34	15.8	-0.1	-0.7

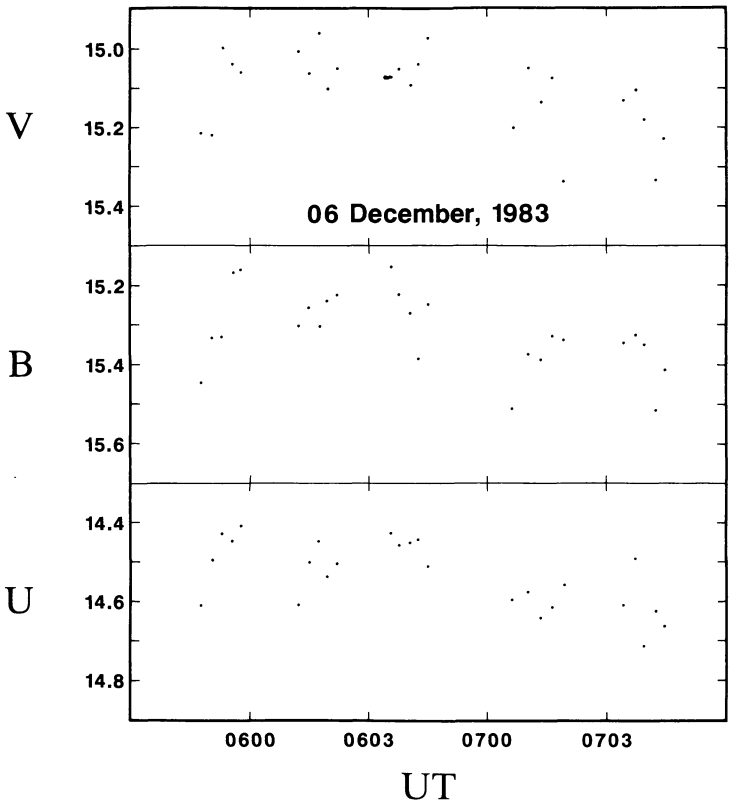

FIGURE 1. — The observations of PG 0244 + 104 obtained on 1983 December 6 are shown. Short-term erratic variations are clearly present in all colors (*UBV*).

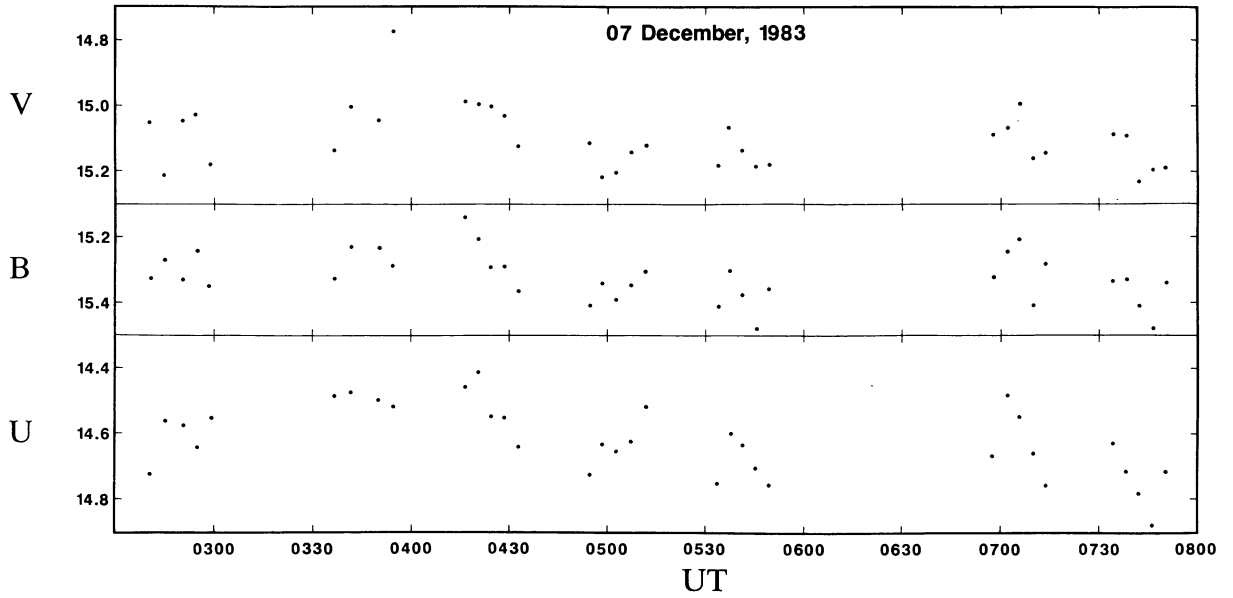

FIGURE 2. — The observations of PG 0244 + 104, which were obtained in all three colors (*UBV*) on 1983 December 7, are found to exhibit rapid variations similar to those observed on 1983 December 6.

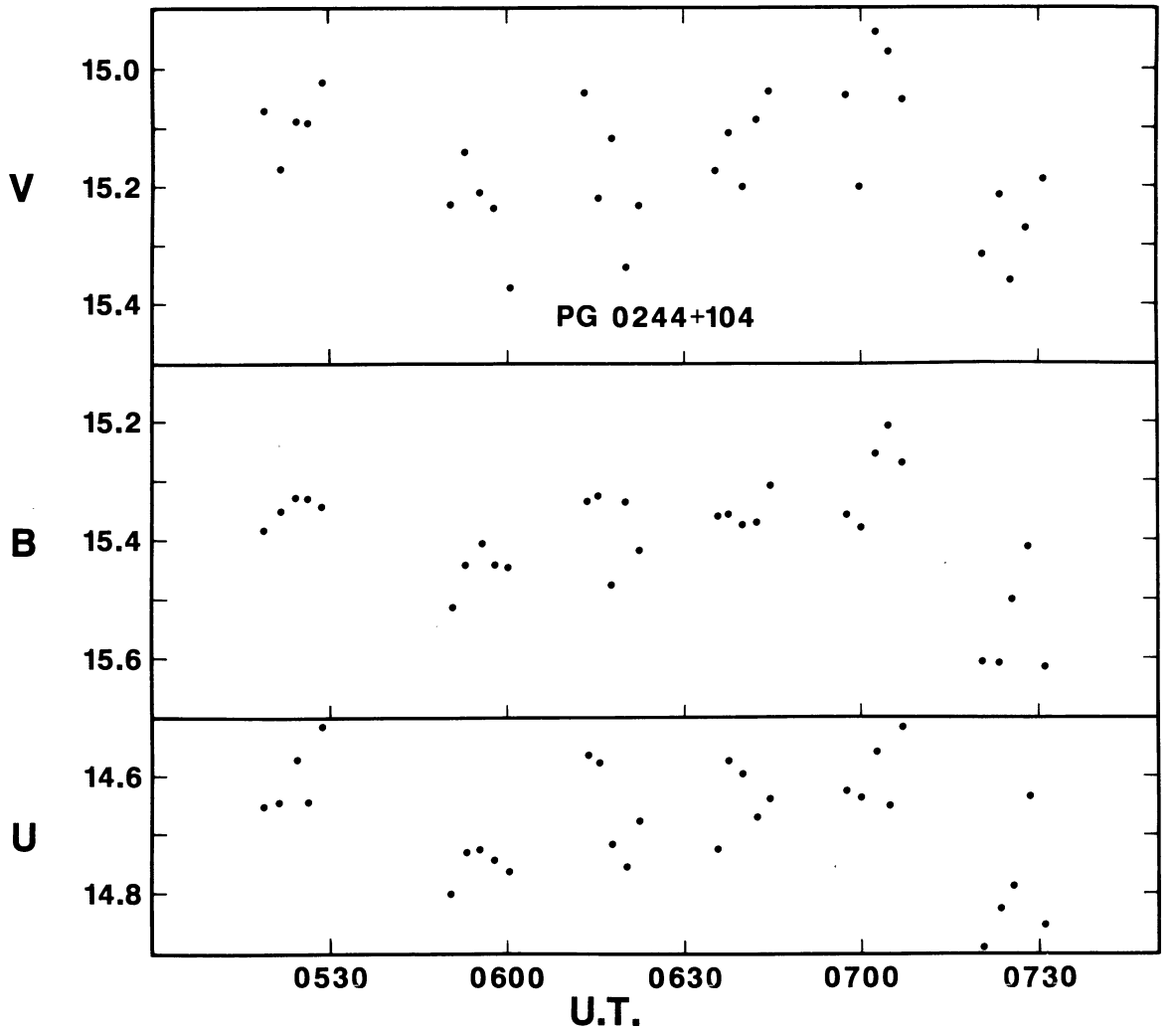

FIGURE 3. — The variability detected for PG 0244 + 104 on 1983 December 8 and presented in the figure above is of larger amplitude than that detected for this star on the two preceding nights.

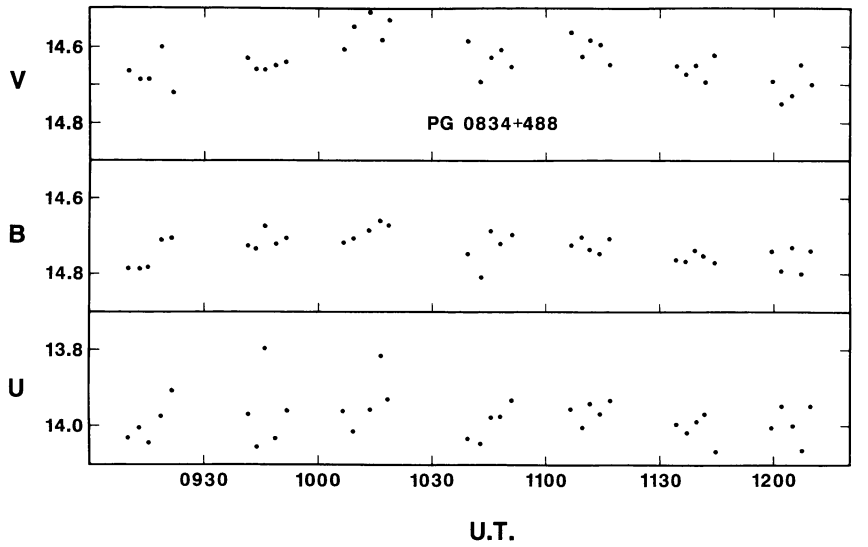

FIGURE 4. — Observations for PG 0834 + 488 were obtained on 1983 December 6. Small amplitude flickering was detected in all three colors (*UBV*).

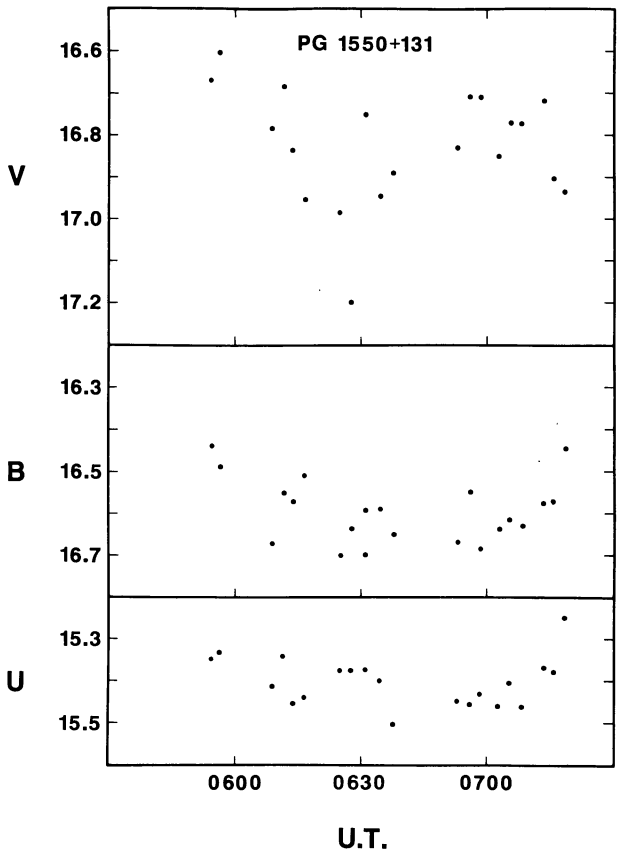

FIGURE 5. — *UBV* observations of PG 1550 + 131 were obtained on 1983 June 9. Variations of up to 0.6 mag on a time scale of minutes are clearly present in the *V* band.

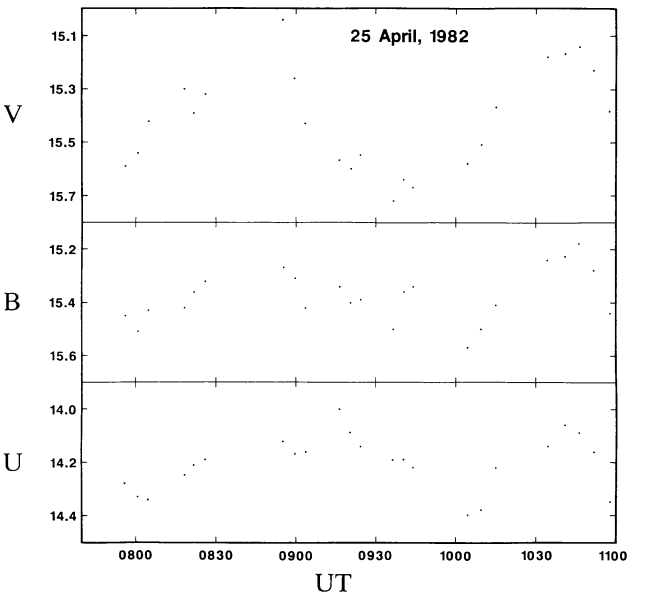

FIGURE 6. — *UBV* observations of the AM Herculis-type binary system PG 1550 + 191 are presented and confirm the 113-minute period for this star.

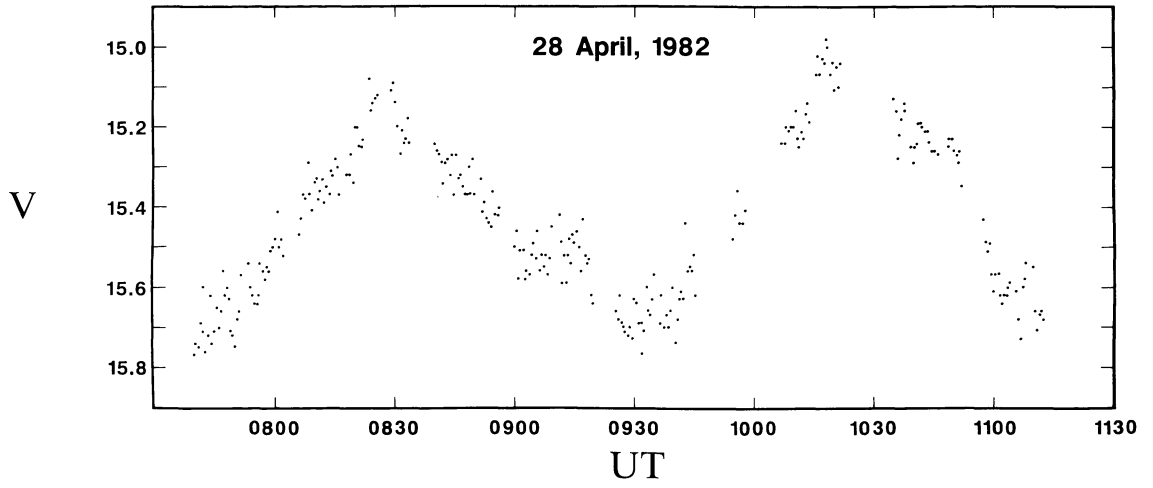

FIGURE 7. — *V* band observations of PG 1550 + 191 confirm the short-term flickering and the periodic variations in the brightness of this star.

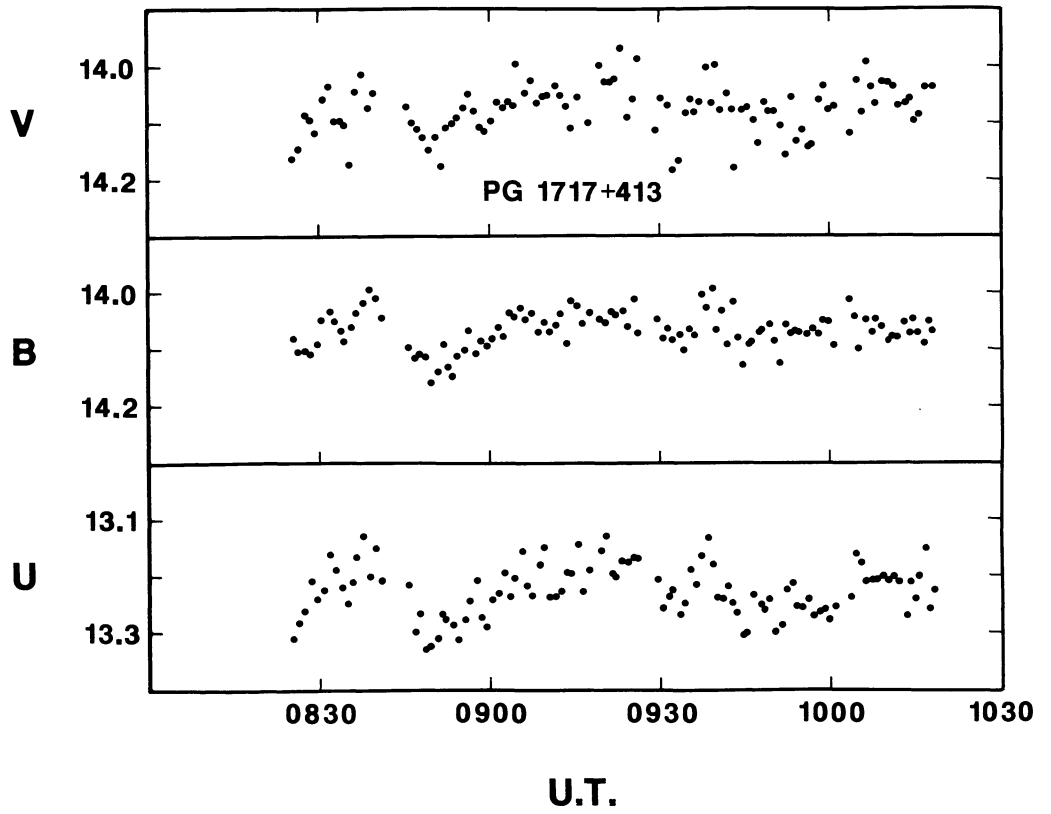

FIGURE 8. — *UBV* observations of PG 1717 + 413 obtained 1983 June indicate low-amplitude flickering in all three colors for this star.

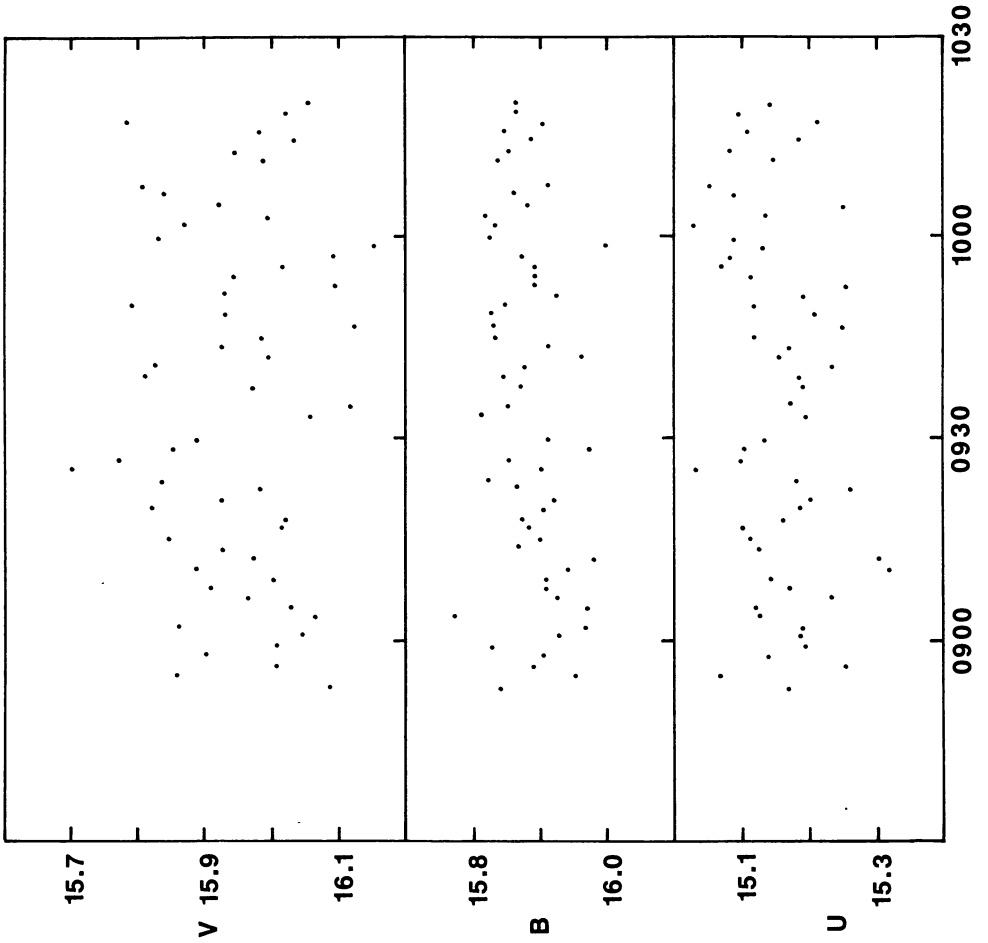

FIGURE 10. — Photometry of PG 2240 + 193 obtained on 1983 June 13 shows variations similar to that observed two nights earlier but the star has brightened by approximately 0.1 mag.

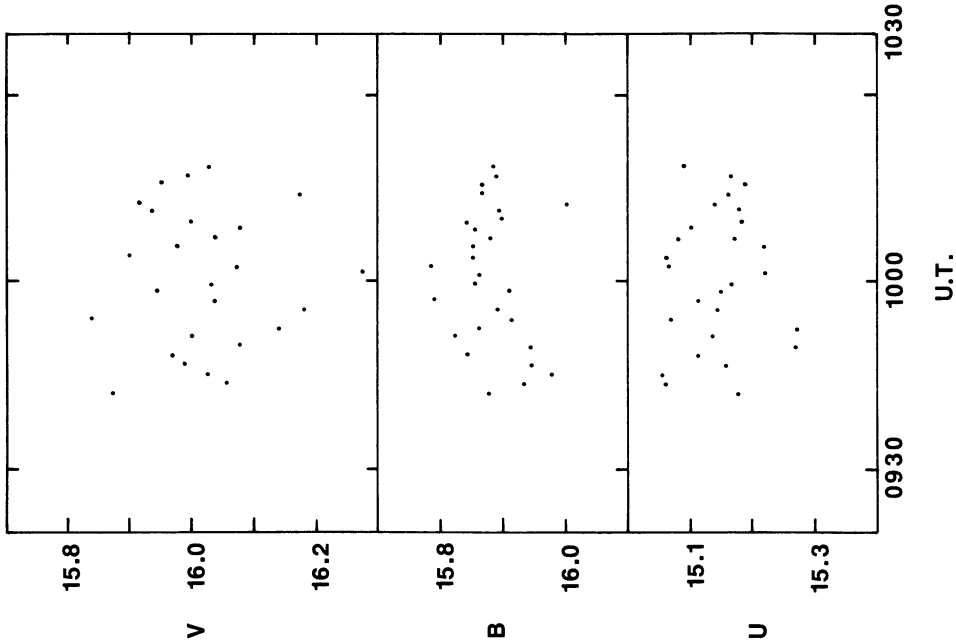

FIGURE 9. — *UBV* photometry of PG 2240 + 193 obtained on 1983 June 11 is presented. Variations of up to 0.4 mag are present in the *V* band.