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ADDITIONAL PHOTOMETRY OF THE OF-TYPE VARIABLE HD 167971

Leitherer et al. (1984) have recently reported the detection of variability in the O8Ib(f) star HD 167971, the brightest member of the young open cluster NGC 6604 and one of the visually most luminous stars in the Galaxy (Humphreys 1978). The purpose of this note is to present additional UBV photometry of HD 167971 which confirms the results of Leitherer et al. for this very massive star.

HD 167971 was observed on 4 nights in March and April 1984 as part of a study of NGC 6604 and the surrounding Serpens OB2 association. The photometry was done with the 0.6m telescope of the University of Toronto at Las Campanas, using a 1P21 photomultiplier cooled with dry ice, and standard Johnson UBV filters. The mean errors of the photometry are estimated to be ± 0.01 in V and B-V, and ± 0.02 in U-B. Subsequent to Leitherer et al.'s announcement, additional UBV data were obtained on 7 nights in August 1984 using the 1.3m and #1, 0.9m telescopes of Kitt Peak National Observatory (KPNO). Both telescopes were equipped with a 1P21 photomultiplier cooled with dry ice, and a standard KPNO UBV filter set which included a blocked (CuSO_4) U filter. The mean errors of the KPNO photometry are ± 0.01 in V and ± 0.02 in B-V and U-B. The results of the Las Campanas and KPNO photometry are given in Table I and illustrated in Figure 1.

The mean magnitude and colours (and their standard deviations) based on all 13 observations are:

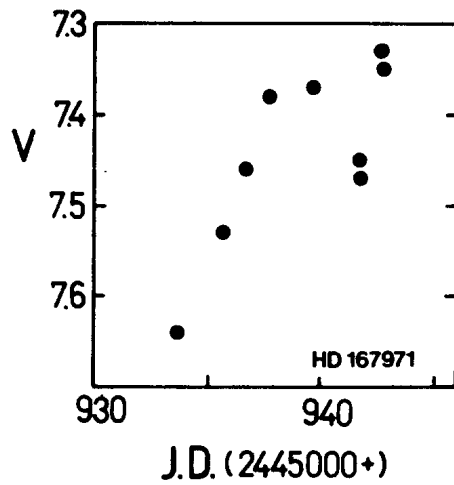
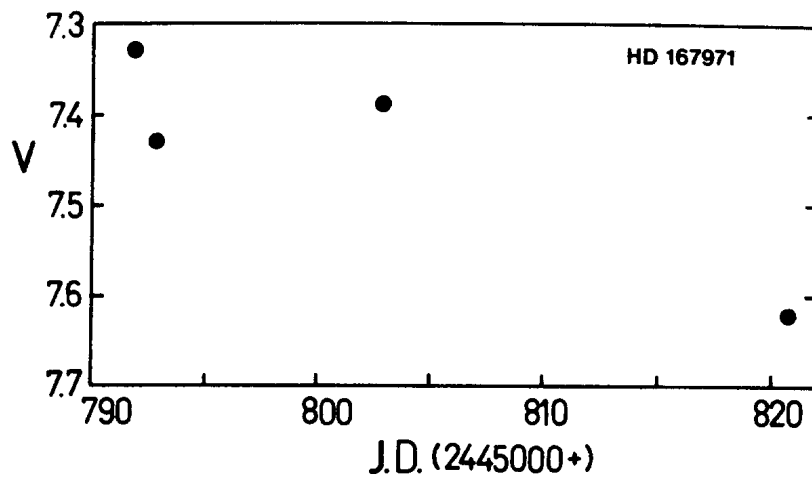


Figure 1: Photoelectric V magnitudes of HD 167971 between JD 2445790 and JD 2445945.

$$\begin{aligned} \langle V \rangle &= 7.442 \pm 0.102 \\ \langle B-V \rangle &= 0.750 \pm 0.017 \quad (n = 13) \\ \langle U-B \rangle &= -0.348 \pm 0.015 \end{aligned}$$

Table I
UBV Photometry of HD 167971

J.D.	V	B-V	U-B
2445791.872	7.33	0.75	-0.34
5792.840	7.43	0.78	-0.33
5802.844	7.39	0.75	-0.34
5820.761	7.62	0.77	-0.33
5933.685	7.64	0.77	-0.35
5935.688	7.53	0.76	-0.34
5936.673	7.46	0.75	-0.33
5937.708	7.38	0.74	-0.37
5939.677	7.37	0.73	-0.36
5941.656	7.45	0.74	-0.36
5941.708	7.47	0.74	-0.36
5942.637	7.33	0.72	-0.37
5942.691	7.35	0.75	-0.35

It is apparent from the data that HD 167971 is variable, with an amplitude of $\sim 0.3^m$, as was first found by Leitherer et al. The mean colours given above differ slightly from those derived by Leitherer et al., presumably as a result of the different photomultiplier/filter combinations used. There is some indication that the star becomes slightly bluer in both B-V and U-B as it brightens in V, but the amplitude of the colour variation ($\sim 0.04^m$) is within the photometric uncertainty.

A check on the reality of the variability of HD 167971 can be made using observations of the nearby (≤ 45 arcsec) star BD-12°4981 (BOV; star "2" of Moffat and Vogt 1975). This star, also a member of NGC 6604, was observed on 10 of the 13 nights listed in Table I, usually just before or after the HD 167971 observation. The mean magnitude and colours for BD-12°4981 are:

$$\begin{aligned}
 \langle V \rangle &= 10.151 \pm 0.014 \\
 \langle B-V \rangle &= 0.612 \pm 0.024 \quad (n = 10) \\
 \langle U-B \rangle &= -0.433 \pm 0.019
 \end{aligned}$$

where the errors quoted are standard deviations of the mean. It is clear that the variability noted for HD 167971 is intrinsic to the star and not the result of extraneous effects. The significant differences between the present photometry and that of Moffat and Vogt (1975) for BD-12°4981 (and, to a lesser degree, for HD 167971) suggest possible systematic errors in Moffat and Vogt's photometry for stars in NGC 6604. This possibility is being investigated as part of the study of NGC 6604 and Ser OB2 now being made.

As Leitherer et al. point out, there had been no indication of photometric variability of HD 167971 prior to their announcement. It is of interest to note, however, that there exists in the literature some evidence for spectrum variations. Walborn (1972) classified the star as O8Ib(f) (a classification that has been generally adopted), and noted the lack of a feature at λ 4686, but the presence of a weak, narrow emission line $\sim 10 \text{ \AA}$ to the blue of that wavelength. Fitzgerald et al. (1979) however give a classification of "O9I(var?)", based on two 74 \AA mm^{-1} spectrograms obtained at the 1.5m telescope at the European Southern Observatory. There appear to be no other indications of spectrum variability among the several other spectral classifications that exist for the star (all of which agree quite well with one another). H β photometry by Moffat and Vogt (1975) and by Crawford (1975) gives $\beta = 2.517$ and $\beta = 2.553$, respectively, suggesting possible changes in the strength of the H β line. Additional H β photometry would be needed to confirm this possibility. The mean of two photographic H γ measures by R.M. Petrie (Crampton et al. 1973) is $\bar{W}_\gamma = 1.7$, which does not appear to be abnormal for the spectral type (Balona and Crampton 1974).

An attempt was made to detect a periodicity in the photometry of Leitherer et al. and this paper combined, but without success. It is evident from the combined data that variations are occurring on a time scale of ~ 1 day, and perhaps as short a time as a few hours. It is hoped that further photometric and spectroscopic observations will allow the cause of the variations in HD 167971 to be determined, and will lead to a better understanding of such very luminous, massive stars.

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