PHOTOMETRY OF BETELGEUSE FROM OCTOBER 1981 TO MARCH 1982

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Abstract

Observations of Betelgeuse in V and B-V from October 1981 to March 1982 are presented, showing variations of brightness and color. Three seasons of observations are summarized. The possible origin of the variations is briefly discussed.

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Presented here is a small sample of data on Betelgeuse taken from October 1981 to March 1982. Table I gives V magnitudes and B-V colors. These photometric data continue the series of observations made by the author with a 6-inch reflector and are based on V = 1.64 and B-V = -0.22 for the comparison star, γ Ori. See Krisciunas (1982) for more details and references regarding data acquisition and reduction.

This season, however, there was a change in the data-taking procedure. We also observed μ Ori as a check star, so as to allow us to measure the V-band atmospheric extinction coefficient k_v. From measurements of μ Ori *versus* γ Ori as a function of air-mass difference over the course of the season, we found that the nights of good seeing (marked by an asterisk in Table I) had $k_v = 0.31$ mag/air mass, while the other nights were consistent with $k_v = 0.46$.

In 1980-1981 we found that the raw color measurements (α Ori *versus* γ Ori) as a function of air-mass difference over the course of the season revealed that on seven of the nine nights the data could be fitted with a straight line, like beads on a string. This fact implies that: 1) the reddening due to our atmosphere was very consistent over the course of the observing season; 2) the raw data on these seven nights could give us the primary atmospheric reddening parameter k'_{bv}; and 3) on these seven nights it is certain that the color of Betelgeuse was constant. In 1981-1982, from a plot of raw differential color *versus* air-mass difference over the course of the season, the data could not be fitted with a straight line; given improvements in our equipment and experience in observing, we feel this difference is most easily attributable to variations in the color of Betelgeuse. (We should have observed the check star in V *and* B, but we felt this additional observation wasted time, and we assumed that any color changes of Betelgeuse would be beyond the capabilities of our equipment to demonstrate.) We derived the data in Table I on the assumption that $k'_{bv} = 2/3\ k_v$. (The factor 2/3 is based on the author's experience observing at sites good enough for all-sky photometry, where the atmospheric extinction and reddening are explicitly measured each night.) We assumed $k''_{bv} = -0.03$ air mass^{-1}. Finally, compared to last season, we used slightly different standardization coefficients to reduce the data: $\epsilon = -0.047 \pm 0.003$; $\mu = 0.960 \pm 0.003$. In Table I and Figures 1 and 2 the error bars are based on the scatter of the raw differential data (mean error of the mean), and are to be considered minimum errors for the standardized results. (The relative errors can be assumed to be much smaller on the basis of the smoothness of the curves.)

Figures 1 and 2 give the data for V and B-V, respectively. This season Betelgeuse was varying smoothly in V, apparently peaking at V ≃ 0.48 on JD ≃ 2445015. In spite of the relative size of the error bars for B-V, we believe these variations are real because of the smoothness of the variations of color. They can be represented by a sinusoid with a period of about 120 days with a peak-to-peak amplitude of $0^{m}.05$ or $0^{m}.06$. These values are consistent with the degree of variation observed by Johnson et al. (1966, Table 4), but their data are too irregularly spaced to be considered a true light curve. The variatons in B-V presented here appear to be uncorrelated with the variations in V.

We would summarize our three years' observations on Betelgeuse as follows: Betelgeuse apparently does not get fainter than V ≃ 0.78 (where it can stay constant for many weeks), but occasionally it gets as bright as V ≃ 0.3. The rate of change of brightness is less than $0^{m}.01$ per day, usually 1/2 to 1/3 this value. B-V can be quite constant, even though V may be varying by quite a bit. However, B-V can also change smoothly, on the order of $0^{m}.05$.

To quote Hayes (1980): "The brightness and photospheric radial velocity [of Belelgeuse] vary with a period of about 2100 days, and with mean amplitudes of about half a magnitude in brightness and 6 km/sec in radial velocity. These long-period variations are accompanied by apparently random light and velocity variations with time scales of a year or less. The systematic long-term variations roughly satisfy the phase relation for a pulsating star (maximum light coincides with minimum radius and vice versa); but the short-term fluctuations are usually uncoupled, except for the most conspicuous changes in which decreasing velocity (outward motion) is accompanied by increasing light." White (1980) claims that the interferometry data give evidence that Betelgeuse varies about 8/44 ≃ 0.18 in radius, based on the 2100 day period of Sanford (1933), but not all authors believe that the interferometry data convincingly demonstrate variations of size for Betelgeuse (e.g., Tsuji 1976). The short-term variations in luminosity and color we have observed could be due to gigantic convection elements in the star (Schwarzschild 1975), or it could be that variations in V and B-V are due to a photospheric outburst in combination with some sort of hole in the dust shell which is known to surround Betelgeuse. Goldberg (1982) suggests that the variations in V could be due to changes in the TiO spectral features. He suggests that variables like Betelgeuse (e.g., μ Cep and CE Tau) be monitored through a carefully chosen set of filters, transmitting radiation in and out of the molecular bands.

It is not known how the variations of Betelgeuse in V correlate with the variations in the infrared. As Betelgeuse has been used as an infrared standard, it would be useful to get some quasi-simultaneous measurements (in BV and JHK) over an observing season or two to investigate this question. Photometric observers might profitably carry out differential photometry in V and B with respect to γ Ori and μ Ori, using μ Ori as a second "program star" measured with respect to γ Ori. This measurement can be made with an uncooled photomultiplier tube and a telescope as small as a 4-inch.

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TABLE I

Photometry of Betelgeuse

Julian Date (2440000 +)	V		B-V	
*4907.97	0.768	±0.011	1.825	±0.020
*4937.80	0.723	0.005	1.806	0.022
4966.72	0.596	0.018		
4972.71	0.565	0.010	1.812	0.019
*4976.66	0.536	0.012	1.826	0.022
4992.82	0.512	0.018	1.838	0.005
4999.79	0.496	0.012	1.843	0.009
5024.67	0.486	0.022	1.870	0.025
5032.67	0.502	0.015	1.823	0.011

* The nights of good seeing.

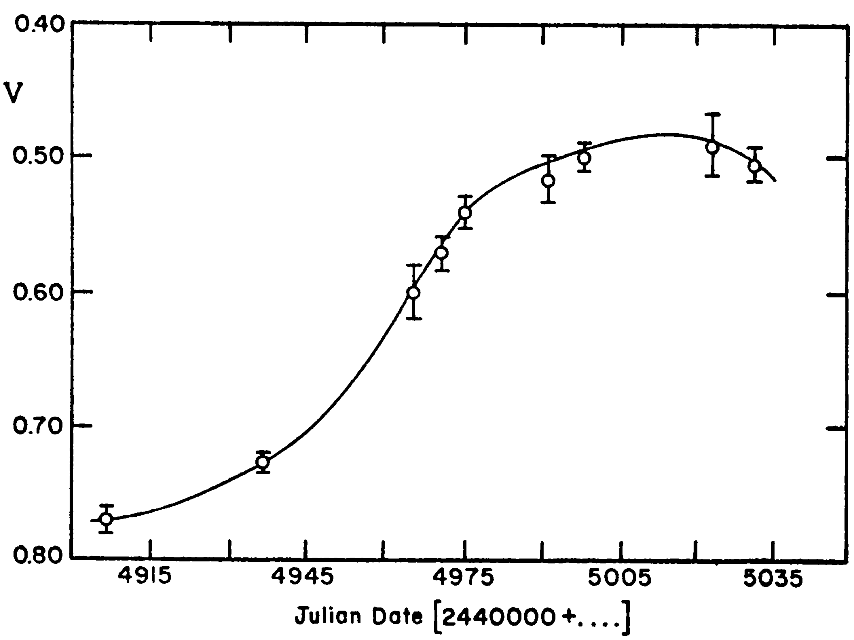

Figure 1. V magnitudes taken from Table I plotted against Julian Date.

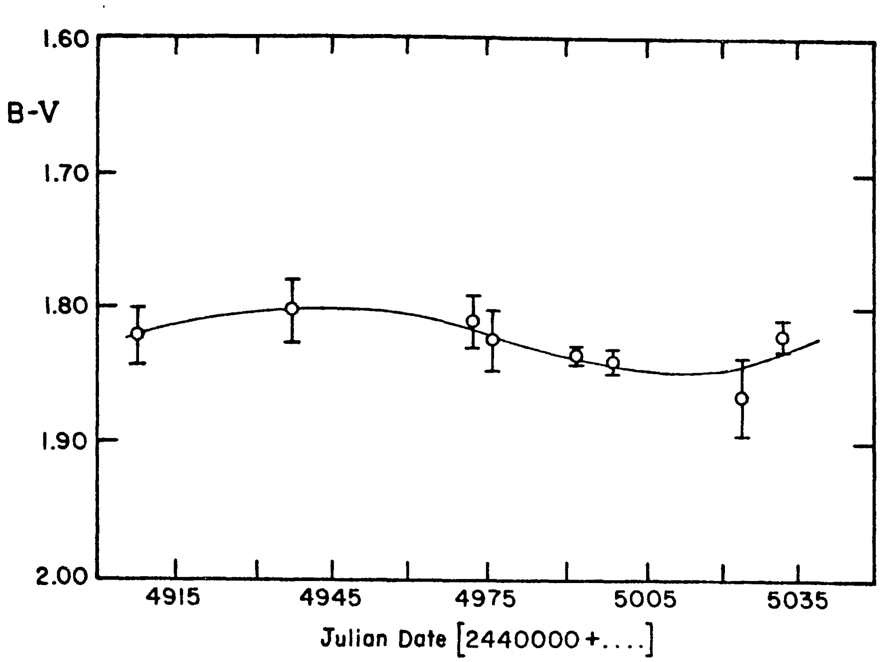

Figure 2. B-V colors taken from Table I plotted against Julian Date.

AN INTERNATIONAL PROFESSIONAL-AMATEUR PHOTOMETRIC CAMPAIGN ON BE STARS

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Abstract

The Be stars are a group of bright B-type stars with emission lines in their spectra. They vary in brightness, by up to a few tenths of a magnitude and on time scales of hours up to years. The nature and cause of this variability are not fully understood. For these reasons, an international professional-amateur photometric campaign has recently been organized by Drs. P. Harmanec, J. Horn, and P. Koubsky of the Ondrejov Observatory of the Czechoslovak Academy of Sciences.

The scope and aims of the photometric campaign are described. The main problems which are encountered in campaigns of this sort - achieving precise observations and reducing them to a standard photometric system - are examined.

Typical light curves of Be stars, obtained with 0.4 m telescopes at the University of Toronto and at the Kitt Peak National Observatory, will be shown.

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