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THE VARIABILITY OF HD 162211 = 87 HERCULIS BETWEEN 1984 AND 1993

The bright K-giant star HD 162211 (= 87 Her = HR 6644) has been used traditionally as the primary comparison star for the UU Herculis-type variable V441 Her = 89 Her since the time of Worley's discovery of the variability in 89 Her (Worley 1956).

HD 162211 was chosen in 1984 as a comparison star for a program seeking long-term luminosity variations in a set of sun-like stars (Radick et al. 1989, Lockwood et al. 1992). After several seasons of data were acquired, a small secular drift was noticed in the brightness and color of the star when compared to two other stable stars. We reported on this change some years ago to John D. Fernie (University of Toronto), who has been using automatic photometric telescopes to monitor V441 Her using 87 Her as the primary comparison star. He reported on the drift as seen in the APT data in Fernie (1991). The change has also been observed by Donahue et al. (1993), who were likewise alerted to the variability from the data to be described here. Since our data have higher precision than the APT data, and cover the longest available baseline using fixed instrumentation, we present here the changes observed in the star from 1984 through the 1993 observing season.

The star was included originally in a trio involving HD 161239 = HR 6608 = 84 Her (the program star) and HD 162076 = HR 6638 (a second comparison star). The results for the program star HD 161239 will be discussed elsewhere and will not be mentioned further here. Because there was some activity in one or both of the comparison stars evident in the first year, a third comparison star (HD 160935 = BD+21°3188) was added from the second year onward. The stars were observed using the Lowell 53cm photometric telescope, which has a permanently-mounted photometer containing an EMI 6256S (S-11) photomultiplier and Strömgren b and y filters. On each night each star was measured twice in each filter using either a 29-arcsec or 49-arcsec diaphragm. Each measure consists of six 10-second integrations on 'star' and two 10-second integrations on 'sky'. The data were reduced to instrumental magnitudes, accounting for differential extinction using mean monthly extinction coefficients (cf. Lockwood & Thompson 1986). During episodes of volcanically-induced enhancements, the extinction values were adjusted to compensate at least approximately for this on a nightly basis, often from a direct determination of the extinction.

Basic data for the variable and two comparison stars are given in Table 1. We measured the stars against Strömgren standards on several nights in July and August 1993, and obtained the V and b-y values listed in the table. Comparable values published by Fernie (1986), Perry (1969), and Olsen (1983, 1993) are shown in the table as well. The standard deviations of the means are given as available in the second line of each entry.

Taylor (1986) considers both HD 162076 and HD 162211 to be supplementary standards on the VRI system. The first is a viable standard from the present differential observations and from those by Percy et al. (1979). But, as will be seen, the magnitude and color variations in HD 162211 are large enough to preclude its use as a high-precision standard star, although any variations are likely to be subdued in the R and I passbands.

Table 1. Basic Data for the Variable and Comparison Stars

Star	V	$b-y$	MK	Source
HD 160935	6.740	0.342	F8IV	Skiff, n=3
	.004	.003		
	6.733	0.347		Olsen (1983), n=3
	.006	.007		
	–	0.348		Perry (1969), n=2
HD 162076	5.693	0.581	G8IV	Skiff, n=3
	.008	.007		
HD 162211	5.091	0.717	K2III	Skiff, n=5, epoch 1993.6
	.001	.005		
	5.063	0.711		Olsen (1993), n=3/5, epoch 1984-85
	.006	.003		
	5.090	0.685		Fernie (1986), epoch 1984.5

The two comparison stars HD 160935 and HD 162076 have been sensibly constant over the most recent nine-season interval (HD 160935 was not added until the second season, as noted above). During this time the mean seasonal differential magnitudes averaged $\Delta y = -1.0495 \pm 0.0015(\sigma)$ and $\Delta b = -0.8297 \pm 0.0017(\sigma)$. Thus it seems reasonable to assume that HD 162076 was the same brightness during the first season. Table 2 summarizes the mean season differential magnitudes for HD 162211 minus HD 162076. The mid-season Julian date is given in the first column; 'n' is the number of nights in each mean.

Table 2. Differential Photometry of HD 162211 minus HD 162076

JD 2440000+	Δy	Δb	n
5884	−0.6387	−0.5247	11
6230	−0.6377	−0.5242	15
6613	−0.6361	−0.5226	11
6959	−0.6331	−0.5183	6
7376	−0.6280	−0.5127	6
7756	−0.6228	−0.5050	7
8062	−0.6104	−0.4903	8
8424	−0.6017	−0.4848	2
8799	−0.6043	−0.4809	9
9152	−0.5995	−0.4760	11

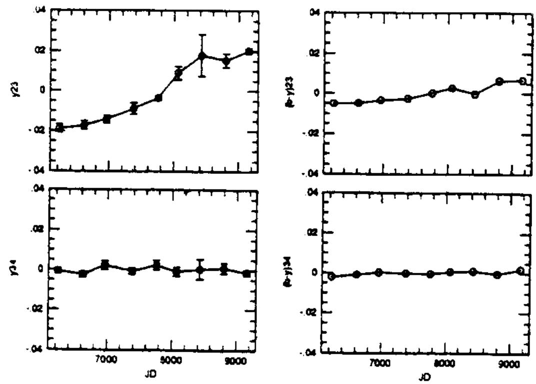

Figure 1

The values in Table 2, normalized to the grand mean, are plotted in Figure 1. The upper panel shows the seasonal means for HD 162211 minus HD 162076 in y and $b-y$; the lower panel shows similar data for the two comparison stars. The error bars represent 95-percent confidence intervals.

HD 162211 has faded by about 0.04 mag. in y and nearly 0.05 mag. in b, i.e. the star has also become 0.01 mag. redder in $b-y$. This is consistent within mutual errors with the standard measures in Table 1 by Olsen and ourselves, and with the extensive APT data presented by Fernie (1991). In contrast, Donahue et al. (1993) claim a brightening of about 0.07 mag. in V for the period 1986-1992 based on a comparison with μ Herculis (86 Her = HD 6623 = HD 161797). Even assuming that a simple sign error was made in the presentation, their claimed amplitude is too large, suggesting a systematic problem in their APT data.

The long-term variations appear to describe half or more of a sinusoid with a period of approximately 15 years. One might simple-mindedly suggest that this represents an example of the warm, low-amplitude end of cyclical, pulsational variations commonly present in M giants. Alternatively, the variation might result from a mechanism more nearly analogous to magnetic-cycle luminosity variations in cool dwarf stars. These sorts of variations in giants are, in any case, previously unexplored because of the long time spans and small amplitudes involved, requiring observations of few-tenths-percent precision over decades-long timescales. In coming years, improvements in the precision of photometry from APTs should allow more such stars to be reliably observed.

Photometry of this star continues as a part of the sun-like stars program at Lowell Observatory. Concomitant high-resolution spectral analysis and radial-velocity monitoring would shed light on the source of the variations.

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