GSC 1377-0969 (Brh V65), GSC 0477-0889 (Brh V100) AND GSC 0669-0674 (Brh V102) ARE NEW W UMa VARIABLES

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The three stars described here result from a programme to discover and classify new variables on the edge of the northern Milky Way. A discussion of the first group of stars and a more detailed description of the programme is given by Bernhard & Lloyd (2000, Paper1). Further information and an up-to-date list of the variables can be found at `http://mitglied.tripod.de/KlausBernhard/index.html` .

The survey and follow-up observations by Bernhard were made using a 20-cm Schmidt-Cassegrain telescope with an unfiltered Starlight Xpress SX CCD camera, with a Sony ICX027B chip. Further details are given in Paper 1. The observations by Frank were made using a 30-cm flat-field camera and an OES-LcCCD11 camera with a Kodak KAF-400 chip. An IR cut-off filter was used for the later observations, those of Brh V100 and V102, but not for V65. The observations of Moschner were made using a 32-cm Ritchey-Chrétien telescope with an unfiltered SBIG ST9 CCD camera and Kodak KAF-0261E chip. All the detectors have a very broad response, peaking near 6000Å, giving approximate V to R-band magnitudes, depending on the colour of the star.

The magnitudes of the variables are determined relative to an ensemble of comparison stars and are then calibrated approximately with respect to one reference star with a GSC magnitude. In most cases small offsets have been applied to correctly align the data due to differences in the instrumental response.

GSC 1377-0969 = Brh V65 (Bernhard 2001a) ($08^h15^m46\overset{s}{.}8 +16°21'57''$ 2000) was re-observed after the survey observations on six nights by Moschner and two nights by Frank in February 2001, and February and March 2002. The reference star used was GSC 1377-0370 ($V \approx 11\overset{m}{.}5$). Brh V65 has $b = 12.3$ and $r = 11.2$ in the USNO A2.0 catalogue, and $B_T = 12\overset{m}{.}2 \pm 0\overset{m}{.}2$ and $V_T = 12\overset{m}{.}3 \pm 0\overset{m}{.}3$ in the Tycho-2 catalogue. The light curve is almost sinusoidal so there is a possible uncertainty of a factor of two in the
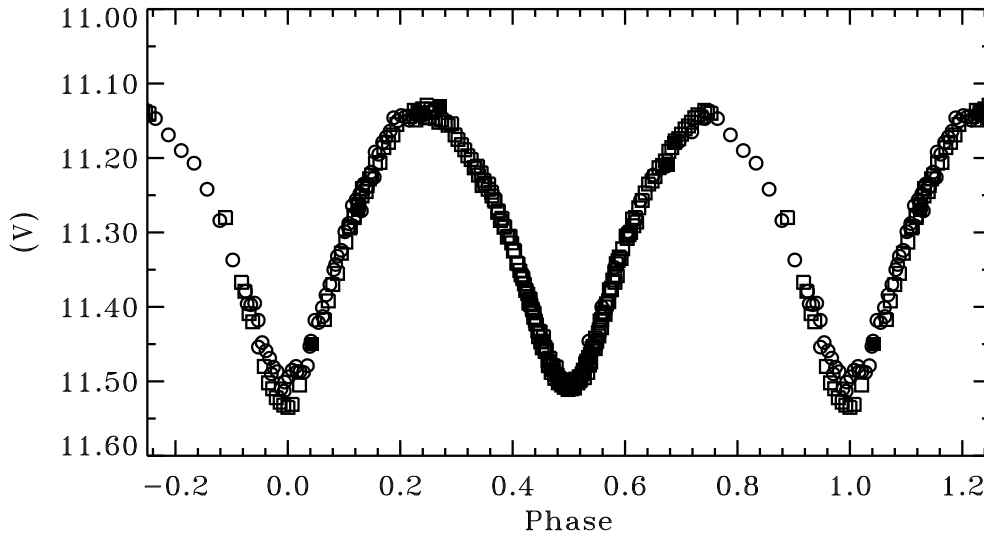
Figure 1. The phase diagram of GSC 1377-0969 = Brh V65 assuming that the reference star GSC 1377-0370 has $V = 11^{m}_{.}5$. The CCD observations of Moschner (open squares), Frank (open circles) and Bernhard (filled circles) are folded with the ephemeris given in the text. No relative offsets have been applied to the major data sets.

Table 1: Brh V65 - Times of minima

HJD	$O - C$	Min	HJD	$O - C$	Min
2451955.3907(2)	+0.0003	II	2452321.3306(2)	−0.0001	II
2451956.3787(2)	−0.0007	II	2452338.3917(8)	+0.0002	I
2451964.2923(4)	+0.0007	II	2452342.3502(8)	+0.0026	I
2451968.4929(10)	−0.0021	I			

period from the photometry alone. However, an almost complete light curve has been observed by Moschner which shows a small difference in alternate minima. The most likely interpretation is that the star is a W UMa variable with almost identical eclipses. The colour, although poorly determined, the range of variation, $0^{m}_{.}35$, and the galactic co-ordinates, $l = 207, b = +26$, are all consistent with this interpretation, and argue against it being a β Cephei or δ Scuti variable. In total seven eclipses have been observed and the times of minima (and errors) are given in Table 1. The light curve is shown in Figure 1 and the ephemeris of primary minimum is given by

$$HJD_{\mathrm{MinI}} = 2451968.495 + 0^{d}_{.}494514 \times E.$$
$$\pm 1 \qquad \pm 2$$

GSC 0477-0889 = Brh V100 (Bernhard 2001b) ($19^{h}26^{m}28^{s}_{.}1$ $+07°11'49''$ 2000, $l = 43$, $b = -4$) is classed as non-stellar in GSC 1.1 and 1.2 and does not appear in the USNO A2.0 catalogue, which does note a faint companion at $8''$ with $r = 14.3$. The star does appear in GSC 2.2 with $b = 12.5$ and $r = 11.3$. Brh V100 was observed on 14 nights during the survey phase and on a further two nights by Bernhard and six nights by Frank, in August 2001. The reference star used was GSC 0477-1815 ($V \approx 11^{m}_{.}1$). The period
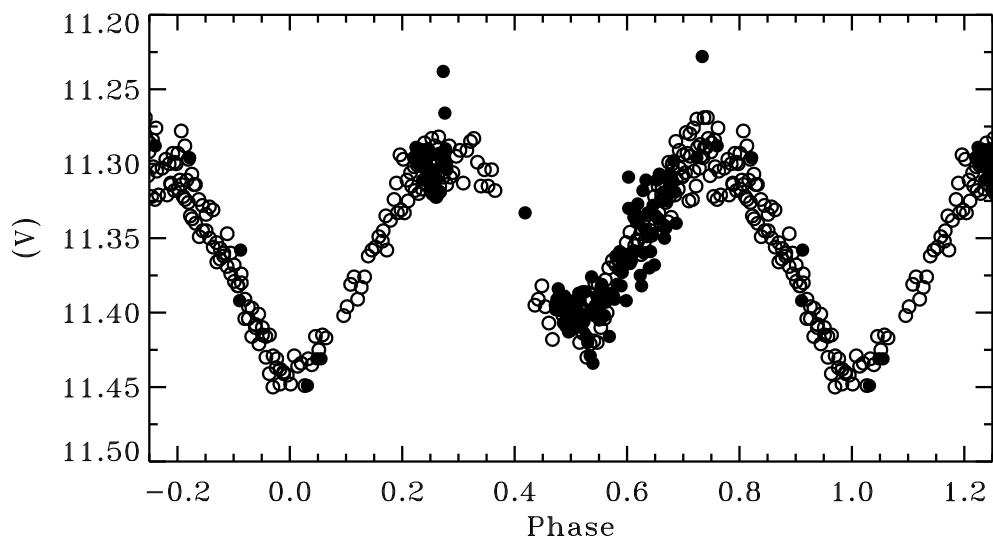
Figure 2. The phase diagram of GSC 0477-0889 = Brh V100 assuming that the reference star GSC 0477-1815 has $V=11^{m}\!.1$. The CCD observations of Frank (open circles) and Bernhard (filled circles) are folded with the ephemeris given in the text.
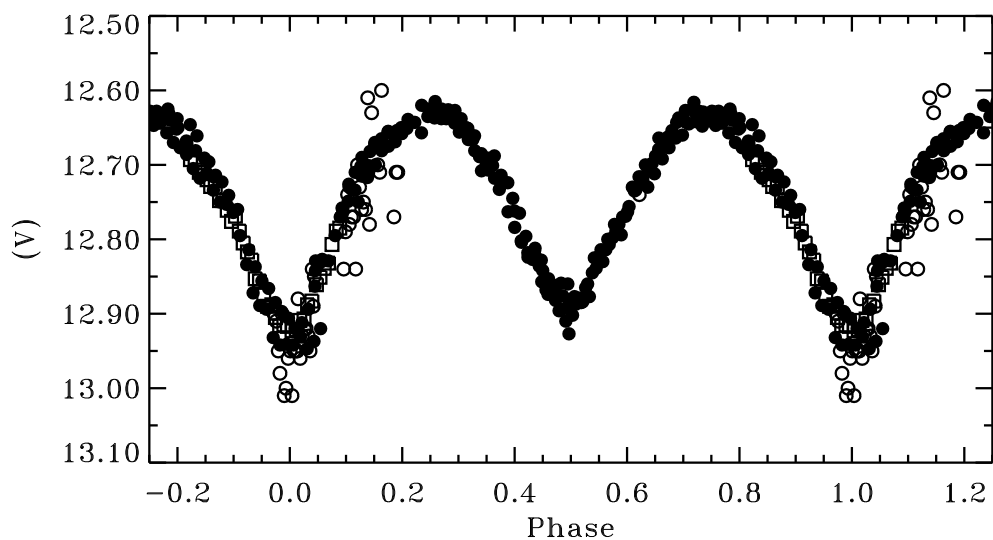

Figure 3. The phase diagram of GSC 0669-0674 = Brh V102 assuming that the reference star GSC 0669-0620 has $V = 12^{m}\!.0$. The CCD observations of Bernhard (open circles), Frank (filled circles) and Moschner (open squares) are folded with the ephemeris given in the text.

has been determined unambiguously and the resulting light curve is shown in Figure 1. The two minima are slightly unequal and suggest that the star is a W UMa variable. The amplitude of $0^{\mathrm{m}}15$ and the GSC 2.2 colour are at least not inconsistent with this interpretation. An almost complete light curve was observed by Frank which shows a small but clear difference in the eclipses. The ephemeris of primary minimum is

$$HJD_{\mathrm{MinI}} = 2452140.960 + 0^{\mathrm{d}}60926 \times E.$$
$$\pm 2 \qquad \pm 6$$

Following the initial observations by Bernhard (2002) GSC 0669-0674 = Brh V102 ($04^{\mathrm{h}}29^{\mathrm{m}}24\overset{\mathrm{s}}{.}9 +09°05'31''$ 2000) was observed on a further night by Moschner and six nights by Frank, during January and February 2002. The reference star used was GSC 0669-0620 ($V \approx 12^{\mathrm{m}}0$). The period of Brh V102 has also been determined unambiguously and the star is also shown to be a W UMa variable with an amplitude of $0^{\mathrm{m}}3$. Frank observed a complete light curve and in this case there is a clear difference between the two minima. The galactic co-ordinates, $l = 186, b = -26$, are consistent with this interpretation. The $b - r$ colour from the GSC 2.2 and USNO A2.0 catalogues is 1.4 and 0.9 respectively, and while not well determined, is also consistent with the classification. Times of minima from six eclipses are given in Table 2. The ephemeris of primary minimum is

$$HJD_{\mathrm{MinI}} = 2452308.291 + 0^{\mathrm{d}}38786 \times E.$$
$$\pm 1 \qquad \pm 3$$

Table 2: Brh V102 - Times of minima

HJD	$O - C$	Min	HJD	$O - C$	Min
2452307.3195(9)	-0.0019	II	2452309.4592(14)	$+0.0046$	I
2452308.2914(7)	$+0.0004$	I	2452310.4216(11)	-0.0026	II
2452309.2610(6)	$+0.0003$	II	2452320.3142(4)	-0.0005	I

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