

uvby photometry of the mCP stars HD 35298, 19 Lyrae, HD 192678, and HR 8216^{*}

S.J. Adelman and R.H. Rice

Department of Physics, The Citadel, 171 Moultrie Street, Charleston SC 29409, U.S.A.

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Abstract. Differential Strömgren *uvby* observations from the Four College Automated Photoelectric Telescope are presented for the mCP stars HD 35298, 19 Lyr, HD 192678, and HR 8216. The period for HD 35298 of 1.85457 days is a revision of North's value while that for 19 Lyr of 7.0980 days is alias of that found by Winzer. HD 192678 is found to be a small amplitude photometric variable with the 6.4186 day period proposed by Leroy from polarization measurements. For HR 8216, observations taken between 1995 and 1998 confirm that the star has remained constant at least since 1990.

Key words: stars: individual: HD 35298; 19 Lyr, HD 192678; HR 8216 — stars: chemically peculiar

Table 1. Photometric groups

HD Number	Star Name	Type	V	Spectral Type
35298		<i>v</i>	7.89	B3VwHe
33647	HR 1690	<i>c</i>	6.67	B9Vn
35640	HR 1806	<i>ch</i>	6.23	B9.5Vn
179527	19 Lyr	<i>v</i>	5.98	B9pSi
181119	HR 7324	<i>c</i>	6.68	A3V
180613		<i>ch</i>	6.79	B9
192678		<i>v</i>	7.35	A4p
194668	HR 7815	<i>c</i>	6.51	B9.5III
193592	HR 7781	<i>ch</i>	5.76	A2Vs
204411	HR 8216	<i>v</i>	5.13	A6pCrEu:
205314	HR 8246	<i>c</i>	5.75	A0V
203746		<i>ch</i>	6.84	A1V

1. Introduction

This paper presents differential Strömgren *uvby* observations of four magnetic Chemically Peculiar (mCP) stars HD 35298, 19 Lyr, HD 192678, and HR 8216. Studies of the mCP stars using data from the Four College Automated Photoelectric Telescope (FCAPT) have both improved our knowledge of their rotational periods and better defined the shapes of their light curves (see, e.g. Adelman & Brunhouse 1998 and references therein). These results can be used to better relate observations taken at different times and to study the period distribution of mCP stars. Their variable light curves provide information concerning the uniformity of the surface abundances. Hydrodynamical processes including diffusion and gravitational settling in radiative atmospheres with strong

magnetic fields most likely produce the anomalous photospheric abundances of the mCP stars. Their abundance distributions are patchy and affect the emergent flux distribution. As their magnetic and rotational axes are not aligned, a distant observer will see photometric, magnetic, and spectrum variability as the stars rotate (Michaud & Proffitt 1993 and references therein).

The FCAPT operated on Mt. Hopkins, AZ between September 1990 and July 1996 and since then on nearby Washington Camp, AZ. After the dark count, the telescope measures the sky-*ch-c-v-c-v-c-v-c-ch*-sky in each filter where sky is a reading of the sky, *ch* that of the check star, *c* that of the comparison star, and *v* that of the variable star. Table 1 contains group (a variable along with two supposedly non-variable stars, the comparison and check, against which the brightness of the variable is compared) information (Hoffleit 1982; Hoffleit et al. 1993). Corrections were not made for neutral density filter differences among the stars of each group. The comparison and check stars were chosen from supposedly non-variable stars in the vicinity of the variable on the sky that had

Send offprint requests to: S.J. Adelman

^{*} Tables 2, 3, 4 and 6 are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via <http://cdsweb.u-strasbg.fr/Abstract.html>

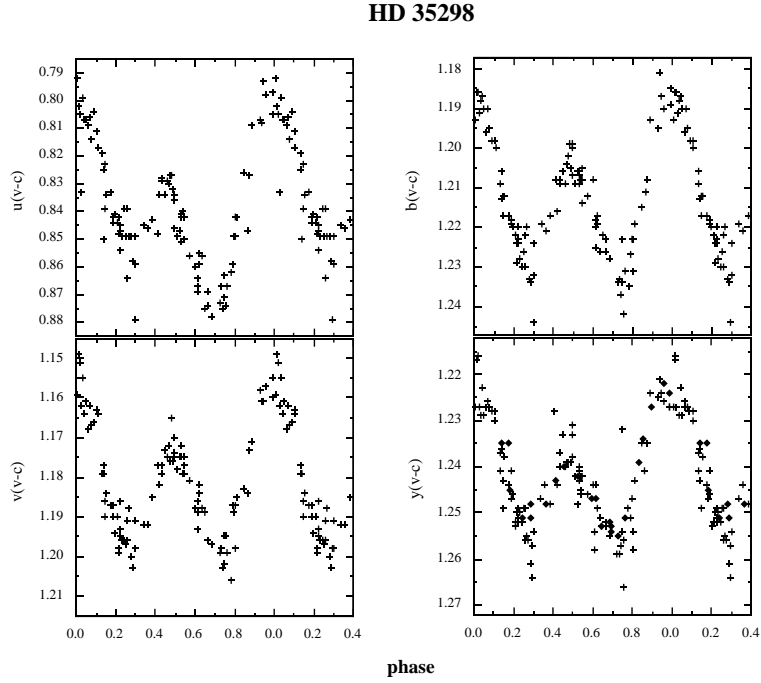


Fig. 1. Photometry of HD 35298 plotted using this paper's ephemeris of HJD (u_{\max}) = 2444973. 886 + 1.85457 E . The FCAPT *uvby* values are indicated by + signs and North's V magnitudes rezeroed to our y magnitudes as closed diamonds

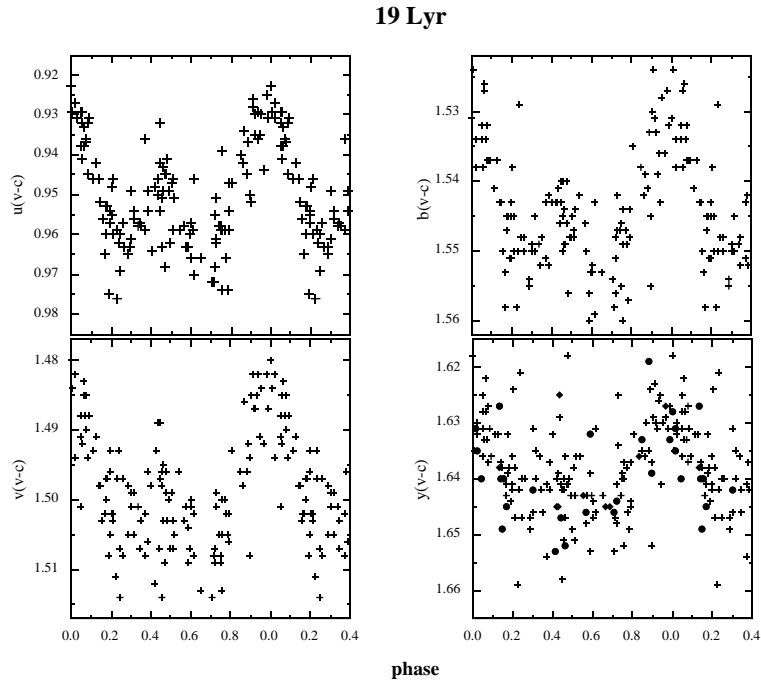


Fig. 2. Photometry for 19 Lyr using the ephemeris HJD (light maximum) = 2441449.99 + 7.0980 E . The FCAPT *uvby* values are indicated by + signs while the V values of Winzer and Burke & Barr rezeroed to the FCAPT y scale are shown, respectively, as closed diamonds and circles

Table 5. Summary of HR 8216's photometry

Heliocentric Julian Date	<i>u</i> <i>v</i> − <i>c</i>	<i>u</i> <i>ch</i> − <i>c</i>	<i>v</i> <i>v</i> − <i>c</i>	<i>v</i> <i>ch</i> − <i>c</i>	<i>b</i> <i>v</i> − <i>c</i>	<i>b</i> <i>ch</i> − <i>c</i>	<i>y</i> <i>v</i> − <i>c</i>	<i>y</i> <i>ch</i> − <i>c</i>
1990-91 3 values								
average	0.013	1.106	−0.311	1.232	−0.416	1.276	−0.478	1.312
std. dev.	0.011	0.006	0.009	0.005	0.006	0.009	0.003	0.005
1991-92 24 values								
average	0.028	1.100	−0.296	1.227	−0.405	1.264	−0.463	1.302
std. dev.	0.003	0.005	0.005	0.005	0.004	0.004	0.004	0.005
1992-93 27 values								
average	0.026	1.105	−0.298	1.227	−0.405	1.265	−0.464	1.305
std. dev.	0.004	0.007	0.003	0.005	0.003	0.005	0.003	0.006
1993-94 13 values								
average	0.029	1.099	−0.296	1.224	−0.404	1.258	−0.464	1.303
std. dev.	0.005	0.009	0.003	0.003	0.002	0.004	0.002	0.008
1994-95 3 values								
average	0.028	1.103	−0.298	1.229	−0.405	1.257	−0.461	1.298
std. dev.	0.002	0.008	0.003	0.002	0.002	0.005	0.002	0.007
1995-96 4 values								
average	0.024	1.116	−0.299	1.267	−0.403	1.260	−0.461	1.308
std. dev.	0.004	0.011	0.001	0.006	0.002	0.004	0.001	0.004
1996-97 42 values								
average	0.032	1.133	−0.297	1.271	−0.412	1.267	−0.469	1.315
std. dev.	0.007	0.006	0.007	0.005	0.003	0.003	0.004	0.005
1997-98 59 values								
average	0.033	1.133	−0.298	1.274	−0.413	1.284	−0.468	1.315
std. dev.	0.005	0.008	0.004	0.007	0.003	0.007	0.003	0.007

similar *V* magnitudes and *B* − *V* colors. Adelman (1998) checked their stability using Hipparcos photometry (ESA 1997). We used the Scargle periodogram (Scargle 1982; Horne & Baliunas 1986) and the clean algorithm (Roberts et al. 1987) in finding periods.

2. HD 35298

North (1984) derived a period of 1.85336 ± 0.00116 days for the Helium weak star HD 35298 (= V1156 Ori = BD +1° 996), a member of the Ori OB1 association. This star exhibits a double-wave light curve with all colors varying in phase. The amplitude is as large as 0.07 mag in the

Geneva photometric system. Borra (1981) measured the magnetic field with essentially this period.

We have 100 differential *uvby* observations, 56 from the 1995-96 and 44 from the 1996-97 observing seasons. A periodogram analysis resulted in a period close to one-half of North's period. But when we plotted the observations, there were two values for each phase indicating that the period was twice that. To have North's *V* values properly zeroed best overlay our *y* values we had to adjust his period slightly. The zero epoch is better taken for maximum light in *u*. Thus

$$\text{HJD } (u_{\text{max}}) = 2444973.886 \pm 0.006 + (1.85457 \pm 0.00001) E.$$

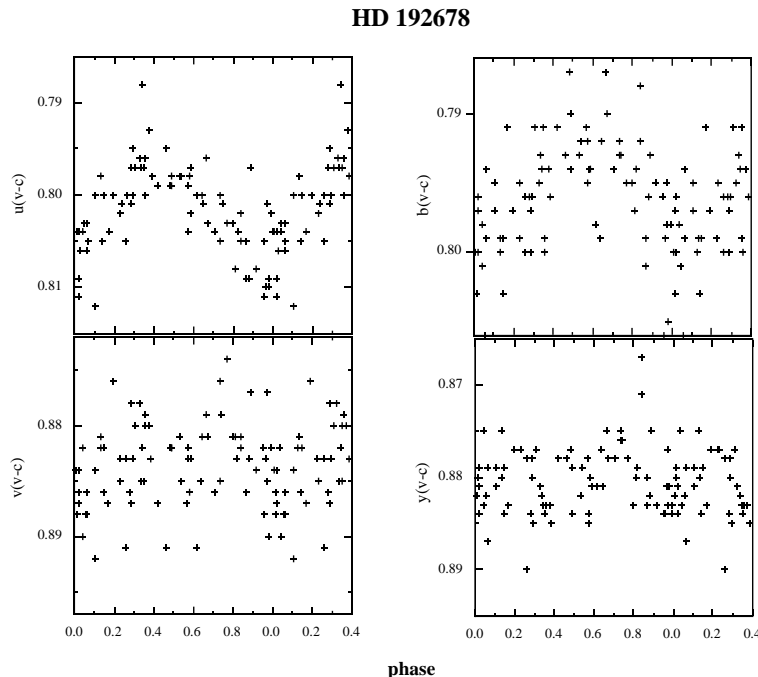


Fig. 3. Photometry of HD 192678 plotted with the ephemeris of Leroy (1995) $\text{JD (magnetic maximum)} = 2444890.17 + 6.4186 E$. The FCAPT *uvby* values are indicated by + signs

Figure 1 shows our FCAPT photometry (+ signs) and North's *V* values (solid diamonds) on our *y* magnitude scale plotted with our ephemeris. The amplitudes are 0.08 mag for *u*, 0.05 mag for *v* and *b*, and 0.037 mag for *y*. The light curves are in phase with two minima and a primary and secondary maxima. Some light curves especially *u* and *v* show additional structure as the star begins the primary minimum. The relative depths of the two minima are more discrepant for *u* than for *v*, *b*, and *y*. We are probably seeing most of the photosphere including both polar regions during the cycle. North's *U* light curve has an amplitude similar to ours, but some of the details near phase 0.5 are not seen probably due to a lesser number of values. Likewise his *B* light curve is similar to our *b*.

3. 19 Lyr

Winzer (1974) discovered the light variations of 19 Lyr (= HR 7283 = HD 179527 = V471 Lyrae) of 0.04 mag in *U* with smaller *B* and *V* amplitudes. His tentative period of 1.1608 days was based upon very limited data. Burke & Barr (1981) obtained additional *UBV* photometry and confirmed Winzer's period.

We obtained differential *uvby* observations of 19 Lyr: 18 in the 1995-96 observing season, 40 in 1996-97, and 66 in 1997-98. The periodogram contains several possible periods of which one near 7.10 days, which is an alias of Winzer's period, is the most likely and consistent with the $v \sin i$ value of Abt & Morrell (1995), 20 km s^{-1} . Using the *V* data of Winzer and of Burke & Barr, we refined the

period. Winzer's zero epoch appeared to be satisfactory. Thus

$$\text{HJD (light maximum)} = 2441449.99 \pm 0.01 + (7.0980 \pm 0.0001) E.$$

Figure 2 shows the FCAPT values as + signs and Winzer's and Burke & Barr's *V* data rezeroed to our *y* scale as solid diamonds and circles, respectively. The variations in *u*, *v*, *b*, and *y* are in phase. The curves suggest possible incipient structure. The amplitudes are 0.045 mag, 0.025 mag, 0.030 mag, and 0.025 mag for *u*, *v*, *b*, and *y*, respectively. There is a sharp primary maximum with a weaker secondary maximum whose prominence decreases with increasing wavelength. Two approximately equal strength minima are symmetrically located with respect to the secondary maximum.

4. HD 192678

Leroy (1995) found the time variations of the Stokes parameters of HD 192678 (= V1372 Cyg = BD +53° 2368) could be described as

$$\text{JD (magnetic maximum)} = 2444890.17 + 6.4186 E.$$

Mathys & Lanz (1992) demonstrated that the determination of its period by Stepien (1968) of order 18 days was incorrect. Wade et al. (1996) presented a magnetic model consisting of an oblique rotating dipole with modified field line inclinations. The dipole has $\iota = 173^\circ$ and $\beta = 120^\circ$. Their ephemeris uses the same period, but a slightly different zero point. Essentially the surface magnetic field is strongest near phase 0.00 and weakest near phase 0.50.

We obtained 77 differential *uvby* observations of HD 192678, 45 during the 1995-96 and 32 during the 1996-97 observing season (Table 4). As our analyses revealed a period close to that of Leroy's, we adopted his ephemeris and found that it was adequate to describe our observations. To improve the period requires photometry for this star over a longer period of time. Figure 3 shows the *uvby* photometry as a function of phase. HD 192678 is brightest in *u* when the surface magnetic field strength is weakest. The amplitude in *u* is 0.017 mag and in *b* is about 0.010 mag while this star is essentially constant in *v* and *y*. The light curves for *u* and *b* are shifted by about 0.15 in phase with *u* reaching its maximum before *b*. This behavior is consistent with the need for a complex magnetic model such as that of Wade et al. (1996).

5. HR 8216

Adelman et al. (1994) presented differential *uvby* photometry of the mCP ultra-sharp lined star HR 8216 (= HD 204411) obtained between 1990 and 1994. The data for the three observing seasons with many observations showed that this star was constant and values in the literature indicate that this has been the case for many additional years. Its constancy has been confirmed also by Hipparcos photometry (ESA 1997). Any evidence of variability can lead to an estimate of its rotational period. Table 5 summarizes the FCAPT photometry. For three of the eight observing seasons, there are only a few observations and differences in $ch - c$ values between these and other years are probably due to their poorer statistics. The 1996-97 and 1997-98 seasons have sufficient observations to clearly show that HR 8216 was constant (Table 6). The telescope being moved just before the start of observing in the fall of 1996 and the order 0.01 mag changes in $ch - c$ values seen between the last two and first 6 observing seasons might simply reflect small errors in the extinction. The offset seen in the $ch - c$ values of *b* is currently unexplained. Comparison of the $v - c$ values for

1991-94 vs. 1996-97 show small offsets in *u*, *v*, *b*, and *y*, respectively of 0.004, 0.000, 0.007, and 0.004 mag. Although these differences are suggestive of possible long term variability, observations in additional years are needed for confirmation.

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