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uvby photometry of the magnetic chemically peculiar stars 63 Andromedae, HD 192913, HR 8240, and 108 Aquarii*

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Abstract. — Differential Strömgren *uvby* photometric observations from the Four College Automated Photoelectric Telescope of four magnetic Chemically Peculiar stars are presented. We refined the period of 63 And to 4.1890 days. The period of the sharp-lined Si star HD 192913 is 16.840 days, a value close to, but slightly different from published values. HR 8240, a sharp-lined Si star, is found not to be a photometric variable. Comparison of four color photometry of 108 Aqr by Morrison and Wolff and from the Four College APT indicates that subtle changes in the shapes of the light curves, especially that for u, have occurred suggesting that this star may be precessing.

Key words: stars individual: 63 And, HD 192913, HR 8240, 108 Aqr — stars: chemically peculiar — stars: variables

1. Introduction

During the first three years (September 1990 – July 1993) of regular operation of the 0.75-m Four College Automated Photoelectric Telescope (FCAPT) on Mt. Hopkins, AZ, we obtained differential photometry of several magnetic Chemically Peculiar stars of the upper main sequence in the Strömgren *uvby* system. The pattern of observing was to measure the dark count and then in each filter the $sky - ch - c - v - c - v - c - v - c - ch - sky$ 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. This paper presents results on four such stars 63 Andromedae, HD 192913, HR 8240, and 108 Aquarii. The observations are given in Tables 1-4 along with their means and their standard deviations. No corrections have been made for neutral density filter differences among each group of variable, comparison, and check stars. However, for 63 And, a change in the neutral density filter was made for comparison star observations during the period under consideration. Thus averages and standard deviations of the averages are given separately for both sets of data.

For each variable star with a known period we plotted our data using the best published period to see if the data approximately confirmed this period. Then we used Fullerton's IDL implementation of the Scargle periodogram (Scargle 1982; Horne & Baliunas 1986) and usually considered our data and those of other observers separately in calculating periodograms. If the periodograms confirmed the published period, then we adjusted the period to make all data coincide as well as possible in phase.

2. 63 And

Adelman, Dukes, and Pyper (1992) found a period of 4.1920 days for 63 Andromedae (= HD 14392 = HR 682). They used *UBV* differential photometry from the Phoenix-10 telescope of Fairborn Observatory. Their adopted period is an alias of that proposed by Winzer (1974) when he discovered the light variability of 63 And. This star has only marginally present λ4200 and λ5200 broad, continuum features (Adelman & Pyper 1993). Bohlender et al. (1993) measured a magnetic field of 360±310 G which is not significant.

Eighty-one *uvby* observations of 63 And were obtained with the FCAPT. The comparison and check stars are 62 And (= HD 14212) and 66 And (= HD 15138), respectively, the stars used by Adelman et al. (1992). A periodogram analysis yielded a period of 4.240 days with the other significant period an alias of the adopted period. When we combined our y data with the V data of Adelman et al. (1992), we found 4.1920 days. To make the V data of Winzer (1974) also coincide in phase required a period of 4.1890 days. To bring the light maximum in y in better agreement with the zero epoch, we increased Winzer's value by 0.42 days. Our adopted ephemeris thus became.

* Tables 1-4 are only available in electronic form: see the editorial in A&A 1992, Vol. 266, No. 2, page E1

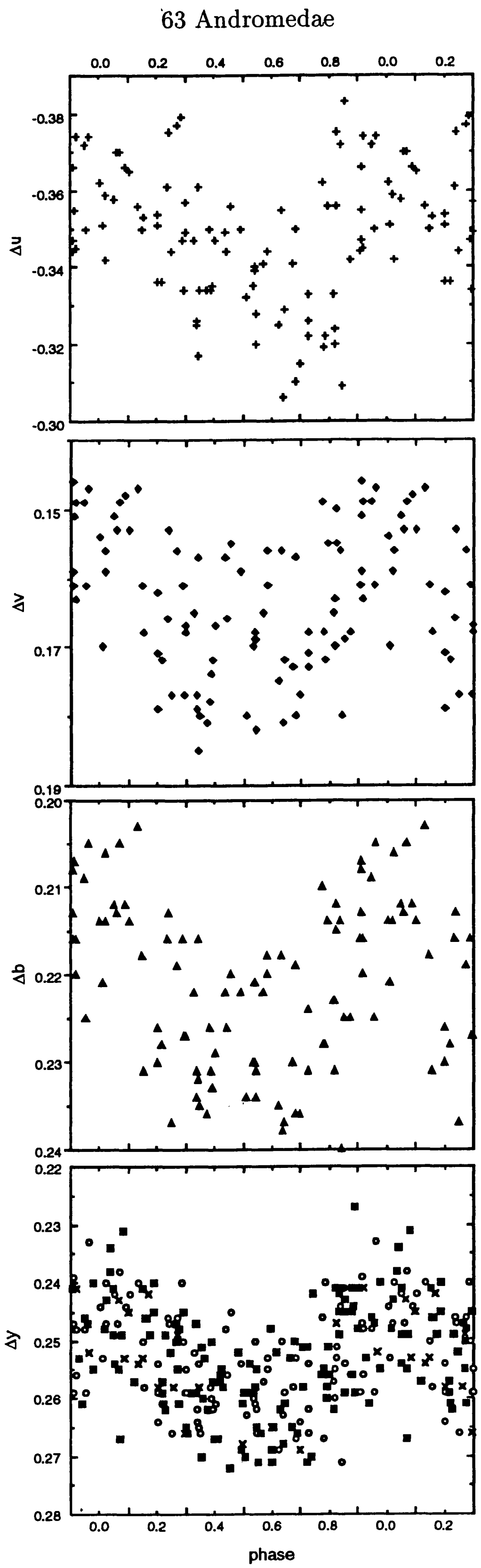

Fig. 1. *uvby* photometry of 63 And plotted according to JD ($y_{\rm max}$) = 2441620.08 + 4.1890E. The V magnitudes of Winzer (1974) and of Adelman et al. (1992) transformed to y are shown as x's and solid squares, respectively, while the FCAPT y values are o's

$$\mathrm{JD}\,(y_{\rm max}) = 2441620.08 + 4.1890E.$$

The amplitude of u is 0.06 mag, of v 0.02 mag, of b 0.02 mag, and of y 0.03 mag (Fig. 1). The u and the y light curves show definite asymmetries with substantially longer falling than rising branches. The v magnitude is marginally variable.

The scatter about the mean light curve is somewhat more than anticipated, but it is similar to that found by Adelman et al. (1992) for *UBV* photometry. The use of a smaller diaphragm than ours (with a diameter of 45") might ameliorate this problem. The improvement of the data quality is a continuing effort of the members of the FCAPT Consortium.

3. HD 192913

HD 192913 is one of the sharpest-lined Si stars with v sin i of 14 km s^{-1} (Preston 1971). Winzer (1974a,b)'s *UBV* photometric measurements showed that this star was a single wave variable with amplitudes of 0.08 mag in U and 0.06 mag in B and V with a period of 16.478 days. However, when his data was tested with a periodogram, his period was not found to be significant. Musielok et al. (1980) used his and their own data to refine the period to 16.846 days. Fifteen spectrophotometric observations (Adelman 1982) showed that this star has a definite λ5200 feature while the other three spectrophometric anomalies are absent (Adelman & Pyper 1993). Ryabchikova et al. (1990) studied the spectrum variability of this star.

Eighty-seven observations of HD 192913 (Table 2) were obtained with the FCAPT during three years with HD 191747 as the comparison and HD 190167 as the check star. Periodogram analyses of each color separately resulted in a period of 16.829±0.002 days which is close to that of Musielok et al. (1980) and an earlier value by Bartolini et al. (1974). When we plotted our y data with Winzer's V values using our period and his epoch so that both sets of data had the same mean, we found a phase shift of 0.25. To bring the data into best agreement, we increased the period to 16.840 days. Thus we adopt as the ephemeris

$$\mathrm{HJD\ (max\ light)} = 2441617.165 + 16.840E.$$

The maxima are symmetric except for possibly v (Fig. 2). The v light curve is the least symmetric. It may exhibit two minima, one of which is about 0.01 mag deeper than the other. The falling branch appears less steep than the rising branch. Suggestions of this behavior are also seen in the u light curve. The amplitudes of variability are 0.07 mag for u, 0.045 mag for v, and 0.06 mag for b and y, which are slightly less than would be anticipated from Winzer's (1974) study.

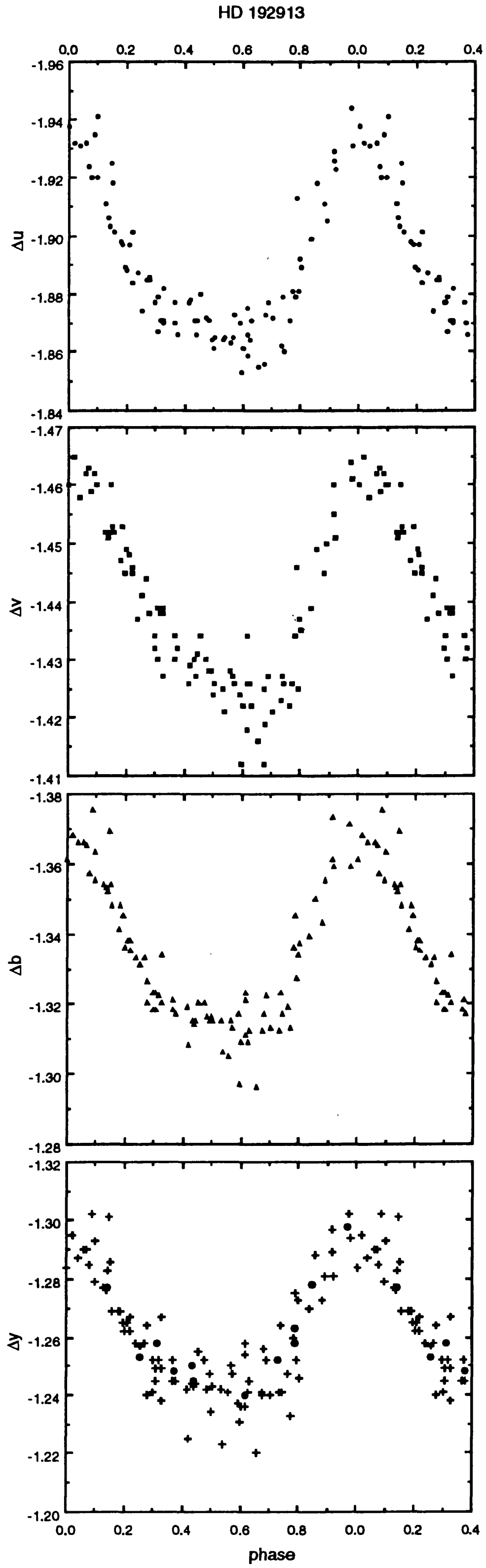

Fig. 2. *uvby* photometry of HD 192913 plotted according to HJD (max light) $= 2441617.165 + 16.840E$. The V magnitudes of Winzer (1974) transformed to y are shown as solid circles while the FCAPT y values are +'s

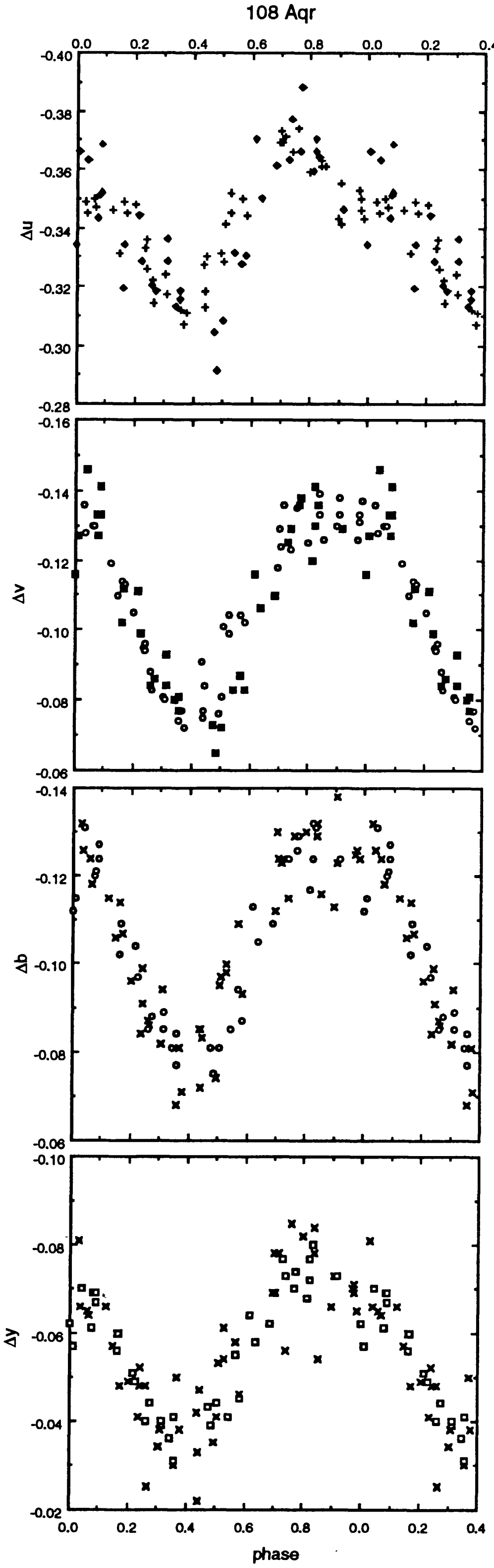

Fig. 3. *uvby* photometry of 108 Aqr plotted according to HJD (phase origin) $= 2444696.820 + 3.735239E$. Data from Morrison & Wolff (1971) transformed to the Four College APT zero points are also shown. For u, MW values are solid diamonds, FCAPT values are +'s; for v, MW values are solid squares, FCAPT values are o's; for b, MW values are o's, FCAPT values are x's, and for y, MW values are open squares, FCAPT values are x's. Shifts between these data sets are seen especially in the rising branch of the u light curves

4. HR 8240

Babcock (1958) noted HR 8240 (= HD 205087) was a suspected magnetic star. Recently Bohlender et al. (1993) measured a field of 640±520 G which is not particularly significant. It is a moderately sharp-lined Si star with $v \sin i = 25$ km s^{-1} and thus may be seen close to a pole-on aspect or simply is an intrinsically slow rotator. Winzer (1974)'s *UBV* photometry from two observing runs did not indicate that the star was variable, but these runs only covered a very limited period. Adelman (1983) obtained 16 spectrophotometric scans. Adelman & Pyper (1993) noted that the λ4200 and λ5200 features were present while the λ3509 and λ6300 features were marginally present.

Our 37 *uvby* observations with the FCAPT show that the standard deviations of the $v - c$ values for each of the four colors are similar to those for the respective ch-c standard deviations. Thus to within the errors of the observations we would not expect any variability, which is confirmed by our periodogram study. Our comparison star was HD 205420 and our check star HD 205541.

5. 108 Aqr

Recently North, Brown, and Landstreet (1992) derived a precise rotational period from Geneva photometry and previously published y photometry especially that of Morrison & Wolff (1971) for the cool magnetic CP star 108 Aquarii (= HR 9031 = HD 223640). Their ephemeris was

$$\text{HJD (phase origin)} = 2444696.820 + 3.735239E.$$

Adelman & Pyper (1993) noted that this star has both λ4200 and λ5200 features along with a marginally present λ6300 feature and lacked the λ3509 anomaly. Although North et al. (1992) have utilized considerable photometry in their period determination, it is worthwhile to confirm their period and to compare our *uvby* photometry with that of Morrison & Wolff (1971) as this might tell us something about the long term stability of 108 Aqr's light curves. Periodogram analyses of our data indicated a period of 3.733 days in good agreement with that of North et al. We obtained 48 values with the FCAPT using HD 222847 as the comparison star and HD 225132 as the check star.

When we use North et al.'s ephemeris and compare our data (Tab. 4) with that of Morrison & Wolff (1971) corrected for zero point shifts, we find generally good, but not perfect agreement. We cannot improve their ephemeris as expected. But compared with Morrison and Wolff's data (Fig. 3) there are some changes in the shapes of the light curves especially a phase shift in the rising branch of the u curve (+'s FCAPT data, solid diamonds from Morrison and Wolff in upper panel) which is less evident in v and b and a perhaps slightly greater amplitude in y. This is similar to the changes in the shape of the light curves of 56 Ari reported by Adelman & Fried (1993) who interpret this type of behavior as due to free body precession of the magnetic CP star. Our knowledge of the spectrophotometric energy distributions of CP stars indicates that this cannot be due to passband differences. Thus additional photometric observations of this star are definitely needed to confirm such variability and then possibly to see how the light curves change each year.

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