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uvby FCAPT Photometry of Six Small-Amplitude mCP Stars

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ABSTRACT. If magnetic fields cause elemental abundances to change in the stellar photosphere, then all magnetic chemically peculiar (mCP) stars should exhibit signatures of this effect in both their spectra and flux distributions. Given that all stars rotate, these stars should be magnetic, spectrum, and photometric variables, albeit sometimes of low amplitude. We study differential Strömgren observations from the Four College Automated Photoelectric Telescope (FCAPT) of α Psc, HR 5857, and HR 6709, which are small-amplitude mCP stars, and AB Cet, HD 15890, and HR 8240, which were thought to be near-constant mCP stars, to determine the periods and amplitudes of their photometric variability. We construct the photometric amplitude distribution functions of the mCP stars studied by the first author to obtain statistics on their photometric variability in Strömgren photometry. The star α Psc has a period of 0.74552 days, with its largest amplitude in *u* of 0.030 mag. The largest amplitude (0.035 mag) for HR 5857 is also for *u*. We confirmed the period of 1.29957 days found by Hatzes using Doppler imaging. For HR 6709 the largest amplitude observed (0.010 mag) is for *u* photometry. Its period is 1.20352 days. AB Cet might be minimally variable. HD 15980 appears to be minimally variable, with a period of at least 5 yr. HR 8240 is variable with a *b* amplitude about 0.05 mag and a period that is several years long. Additional observations of these six stars would be useful to confirm their characteristics. Two apparently constant stars studied with FCAPT Strömgren data, HD 11187 and HD 50169, should be checked to see whether they are long-period variables. If additional observations show their variability, then all mCP stars observed photometrically by the first author with the FCAPT will be found to be variable.

Online material: color figures, machine-readable table

1. INTRODUCTION

Single-channel differential Strömgren *uvby* photometry from the Four College Automated Photoelectric Telescope (FCAPT) at Washington Camp, AZ, is presented for the first time for what were thought be three small-amplitude magnetic chemically peculiar (mCP) stars: α Psc, HR 5857, and HR 6907. New observations of the constant or near-constant mCP stars AB Cet, HD 15980, and HR 8240 are also examined. These investigations continue the studies of the photometric variability of mCP stars. Observationally, the smallest maximum photometric amplitude (of the order of 0.015 mag) of the stars of this series was found both for HR 1094 (Adelman 1999) using the magnetic period (Hill & Blake 1996) and for HD 192678 (Adelman 2006) using the Scargle periodogram (Scargle 1982; Horne & Baliunas 1986). Previous photometric studies of mCP stars with FCAPT data improved their periods and light curves (see, e.g., Adelman et al. 1999), which relate observations taken at different times. Observations taken in different observing seasons can be used to find variable light curves. To test mCP star theories surface maps of abundances can be produced from spectra for those stars that exhibit moderate rotation.

Table 1 (Hoffleit 1982; Hoffleit et al. 1983; SIMBAD) contains photometric information on the six stars with observations presented in this paper. The FCAPT measures the dark count and then in each filter sky-ch-c-v-c-v-c-v-c-ch-sky for each group of variable (v), check (ch), and comparison (c) stars, where sky is a reading of the sky. Corrections were not made for any neutral density filter differences among the stars of each group. The comparison and check stars were chosen from presumably nonvariable stars according to *Hipparcos* photometry (ESA 1997) that are near the variables on the sky with similar V magnitudes and $B-V$ colors. To find the rotational periods the Scargle periodogram was used for α Psc, HR 5857, and HR 6907 and the CLEAN algorithm (Roberts et al. 1987) for HR 6709. Table 2 contains the new FCAPT photometry of this paper. The first observing season was fall 1990 through spring 1991.

If a star is classified as a mCP star, this designation also means that this star has a magnetic field even if it has not been detected. Hydrodynamical processes, especially radiative diffusion and gravitational settling, in radiative envelopes containing strong magnetic fields, are thought to produce their anomalous photospheric abundances (usually with greater than solar values) that are functions of both the local magnetic field strength and the time since the star was on the zero-age main sequence (Michaud & Proffitt 1993 and references therein).

TABLE 1
PHOTOMETRIC GROUPS

HD Number	Star Name	Type	V	Spectral Type	Filter
12447	α Psc	v	4.33	A0 pSiSr	3
12573	60 Cet	c	5.43	A5 III	2
15004	71 Cet	ch	6.33	A0 III	2
15144	AB Cet	v	5.83	A6 Vp	1
15130	72 ρ Cet	c	4.89	B9.5 Vn	2
17081	π Cet	ch	4.25	B7 V	3
15980	BD +39 571	v	7.89	Ap Si	1
16219	HR 760	c	6.54	B5 V	1
16004	HR 746	ch	6.36	B9 pHgMn	2
140728	HR 5857	v	5.51	B9 pSiCr	2
139493	HR 5818	c	5.74	A2 V	2
141675	HR 5887	ch	5.86	A3 m	2
164258	HR 6709	v	6.37	A3 pSrCrEu	1
163624	HR 6689	c/ch	5.97	A3 V	2
166917	BD+2 3528	ch/	6.70	B7 V	1
164577	68 Oph	/c	4.45	A2 Vn	2
205087	HR 8240	v	6.70	B9 pSiSrCr	1
205420	HR 8250	c	6.47	F7 V	1
205541	HR 8258	ch	6.11	A4 V	1

NOTES.—Type: v = variable, c = comparison star, and ch = check star. Filters: 1 = no neutral density filter, 2 = 1.25 mag neutral density filter, and 3 = 2.50 mag neutral density filter.

Such fields produce abundance "spots" and via line blocking and flux redistribution produce changes in the energy distributions that can be detected by photometry and even better by spectrophotometry. As their magnetic and rotational axes are not usually aligned, a distant observer can see a variety of variability as they rotate. Thus, the mCP stars are photometric, spectrum, and magnetic variables with their emergent energy distributions, photospheric abundances, and magnetic field strengths dependent on photospheric location. The detectability of the variability depends on the type of observation and the signal-to-noise ratio (S/N). With high-quality observations made with intermediate-band photometry the limits on the photometric variability should be of the order of 0.005 mag. We assemble the distribution functions of amplitudes and investigate the observations of near-constant mCP stars to see whether it is probable that all mCP stars are photometric variables. By confining our analysis to those stars with FCAPT data, we are not using considerable useful data in the literature. However, finding errors for the photometry of others can be quite difficult. To check the constancy of mCP stars may require that one look for long-term periods and furthermore that one carefully examines those mCP stars with stable photometric colors.

Adelman's ensemble of mCP stars has some biases. At the start of FCAPT operations in 1990, he and D. Pyper Smith split the interesting mCP stars between them. Using the Ph.D. thesis of Winzer (1974), he tried to select those stars with decent photometric amplitudes while she was more interested in the well-studied mCP stars. He later added some mCP stars from Paunzen & Maitzen (1998), who had gone through the *Hipparcos* photometry (ESA 1997; see also ESA 1998) to find new mCP photometric variables.

2. THE SMALL-AMPLITUDE mCP STARS

The observing season standard deviations of the means for the four Strömgren magnitudes are a consideration for further data analysis. If one of the four v−c means has a standard deviation of the mean somewhat larger than that for the corresponding value of ch−c, then the star should have at least a moderate amplitude sufficient for a good period determination. Preston (1970) suggested a search for long-term periods among those mCP stars of the SrCrEu subtype that exhibited spectral lines with $v \sin i$ less than 10 km s^{-1}. Two stars that satisfy his expectations are HD 9996 (Preston & Wolff 1970) and HD 204411 (Adelman 2003). A few others have been recognized as roAp stars, which have very short periods (e.g., 33 Lib [Kurtz 1991] and γ Equ [Savanov et al. 2006]). Even with these eliminated from the potential long-period mCP stars, still other candidates can be found by examining the photometry.

Our recent assessment of The Citadel's share of unpublished

TABLE 2
NEW *uvby* PHOTOMETRY OF SIX SMALL-AMPLITUDE mCP STARS

HJD	u (v−c)	u (ch−c)	v (v−c)	v (ch−c)	b (v−c)	b (ch−c)	y (v−c)	y (ch−c)
α Psc								
2,449,985.8642	−2.073	−0.266	−1.771	−0.680	−1.711	−0.354	−1.627	−0.103
2,449,993.8426	−2.066	−0.241	−1.779	−0.651	−1.707	−0.344	−1.624	−0.091
2,449,996.8655	−2.051	−0.264	−1.760	−0.673	−1.686	−0.371	−1.606	−0.109
2,450,000.9109	−2.051	−0.258	−1.765	−0.666	−1.703	−0.358	−1.625	−0.109
2,450,001.9104	−2.056	−0.253	−1.772	−0.666	−1.705	−0.355	−1.616	−0.098
2,450,003.9005	−2.050	−0.251	−1.751	−0.670	−1.695	−0.335	−1.600	−0.086
2,450,004.8925	−2.071	−0.248	−1.793	−0.645	−1.727	−0.339	−1.645	−0.087
1995–1996:								
Average	−2.060	−0.254	−1.770	−0.665	−1.705	−0.351	−1.621	−0.097
Standard deviation	0.009	0.008	0.013	0.011	0.012	0.011	0.014	0.009

NOTE.—Table 2 is published in its entirety in the electronic edition of *PASP*. A portion is shown here for guidance regarding its form and content.

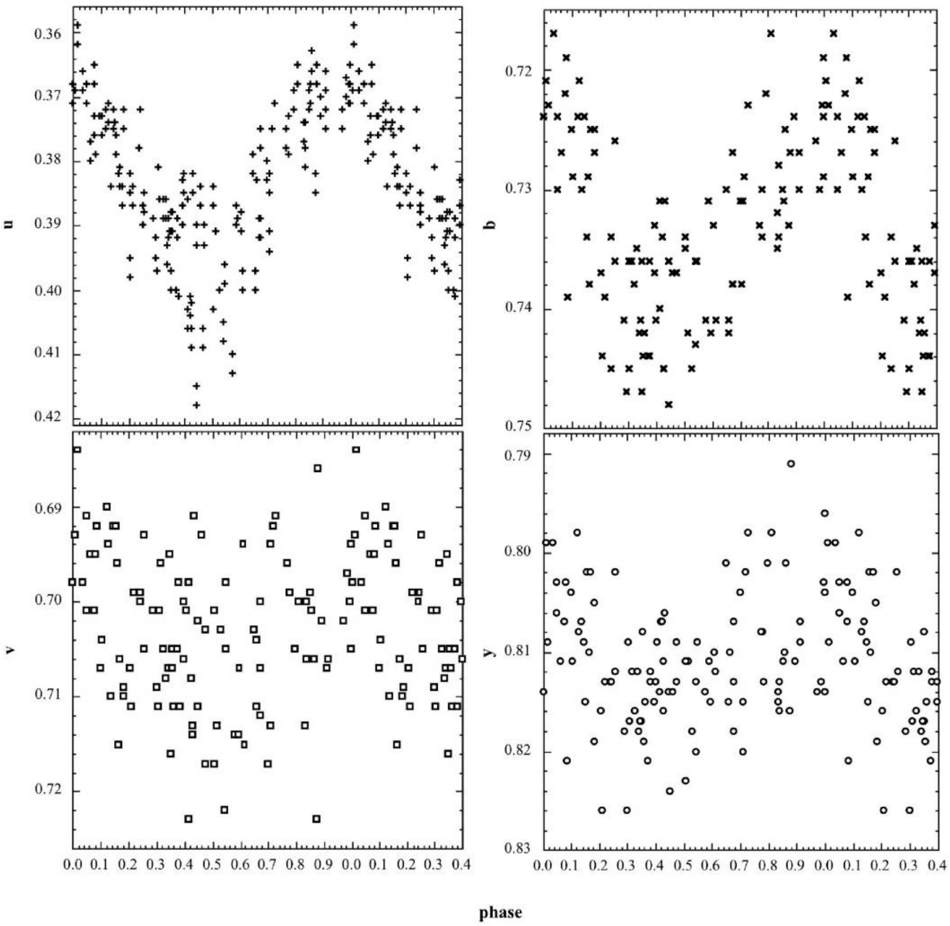

FIG. 1.—Differential FCAPT *uvby* photometry of α Psc according to the ephemeris HJD (phase zero) = 2,451,086.90640 + (0.74552 ± 0.00006)*E*. The *u*-, *v*-, *b*-, and *y*-values are represented by plus signs, squares, crosses, and circles, respectively.

FCAPT photometry indicated that the data for three mCP stars, α Psc, HR 5857, and HR 6907, had standard deviations of their mean *uvby* values that were just larger than those for their ch−c values. When their photometry was examined, periods were found. The Appendix contains their Scargle periodograms, along with some statistical information. The seasonal means and standard deviations for the first two stars, along with those of HR 8240, are in Table 3. AB Cet and HR 6709 are the only minimally variable mCP stars observed by the first author with the FCAPT having a maximum amplitude less than or equal to those of HR 1094 and HD 192678.

2.1. α Psc

The spectroscopic binary α Psc A (=HD 12447 = HR 596) is a $V = 4.33$ mag A0 pSiSr star in a binary system 2.0″ from $V = 5.34$ mag α Psc B (=HD 12446 = HR 595), whose spectral type is A3 m. Both components contribute to the photometry. Winzer (1974) on the basis of 15 *UBV* observations found that it was variable, with the largest amplitude 0.03 mag in *U* and a period of 0.7383 days. HD 13467, the comparison star, might be variable. However, its *Hipparcos* photometry suggests that it is constant. FCAPT photometry was obtained in seasons 6 (seven observations), 7 (three observations), 8 (34 observations), 9 (29 observations), 10 (44 observations), and 11 (31 observations). Different filter combinations were used in seasons 6, 7, and 8 and seasons 9, 10, and 11. We studied the later set. Examining the *u*-values with a Scargle periodogram, we found a period of 0.74552 days. Its power S/N was somewhat greater than those with a frequency larger than 1 day^{-1}. Its rotational velocity of 81 km s^{-1} (Royer et al. 2002) does not indicate a long or very short rotational period. For the zero point of our ephemeris we arbitrarily selected the time

TABLE 3
SMALL-AMPLITUDE AND NEAR-CONSTANT mCP MEANS AND STANDARD DEVIATIONS

	u(v−ch)		v (v−ch)		b (v−ch)		y (v−ch)	
				AB Cet				
1990–1991 (8 obs.):								
Average	1.184	…	1.193	…	1.017	…	0.950	…
Standard deviation	0.006	…	0.007	…	0.005	…	0.008	…
1993–1994 (38 obs.):								
Average	1.188	…	1.190	…	1.026	…	0.958	…
Standard deviation	0.006	…	0.005	…	0.004	…	0.006	…
1994–1995 (38 obs.):								
Average	1.192	…	1.192	…	1.032	…	0.964	…
Standard deviation	0.006	…	0.006	…	0.006	…	0.005	…
1995–1996 (5 obs.):								
Average	1.193	…	1.200	…	1.036	…	0.968	…
Standard deviation	0.007	…	0.003	…	0.009	…	0.009	…
	u (v−c)	u (ch−c)	v (v−c)	v (ch−c)	b (v−c)	b (ch−v)	y (v−c)	y (ch−c)
1998–1999 (13 obs.):								
Average	−1.236	1.288	−1.264	0.738	−1.399	0.681	−1.456	0.639
Standard deviation	0.003	0.005	0.004	0.004	0.005	0.003	0.005	0.003
2003–2004 (11 obs.):								
Average	0.156	0.130	0.098	−0.431	−0.122	−0.519	−0.220	0.592
Standard deviation	0.010	0.008	0.011	0.007	0.012	0.008	0.012	0.007
2005–2006 (20 obs.):								
Average	0.151	0.134	0.101	−0.418	−0.127	−0.512	−0.231	−0.580
Standard deviation	0.007	0.005	0.008	0.006	0.005	0.005	0.007	0.007
				HD 15980				
1995–1996 (13 obs.):								
Average	1.945	−0.023	1.471	0.149	1.365	0.170	1.388	0.189
Standard deviation	0.007	0.006	0.005	0.003	0.006	0.005	0.007	0.004
1996–1997 (34 obs.):								
Average	1.932	−0.027	1.473	0.147	1.363	0.169	1.388	0.187
Standard deviation	0.003	0.003	0.003	0.003	0.003	0.002	0.005	0.003
1997–1998 (48 obs.):								
Average	1.923	−0.027	1.471	0.147	1.361	0.169	1.388	0.187
Standard deviation	0.004	0.005	0.004	0.004	0.002	0.003	0.002	0.002
2003–2004 (22 obs.):								
Average	1.923	−1.076	1.454	−0.951	1.340	−0.978	1.362	−0.992
Standard deviation	0.006	0.006	0.006	0.007	0.009	0.006	0.008	0.007
2004–2005 (21 obs.):								
Average	1.938	−1.078	1.458	−0.955	1.349	−0.984	1.374	−0.997
Standard deviation	0.010	0.004	0.010	0.004	0.014	0.005	0.012	0.005
2005–2006 (18 obs.):								
Average	1.944	−1.083	1.455	−0.955	1.342	−0.983	1.366	−0.998
Standard deviation	0.003	0.003	0.004	0.003	0.004	0.003	0.003	0.004
2006–2007 (25 obs.):								
Average	1.949	−1.073	1.450	−0.945	1.337	−0.972	1.356	−0.982
Standard deviation	0.005	0.008	0.007	0.008	0.009	0.007	0.008	0.008
				HR 8240				
1990–1993 (27 obs.):								
Average	−0.589	0.315	−0.512	0.717	−0.144	0.477	0.233	0.241
Standard deviation	0.007	0.005	0.005	0.004	0.004	0.004	0.004	0.004
1993–1994 (7 obs.):								
Average	−0.587	0.310	−0.508	0.713	−0.145	0.479	0.232	0.247
Standard deviation	0.016	0.008	0.003	0.006	0.002	0.004	0.006	0.008
1994–1995 (5 obs.):								
Average	−0.591	0.307	−0.504	0.709	−0.138	0.472	0.237	0.244
Standard deviation	0.005	0.008	0.001	0.005	0.002	0.007	0.003	0.002
2005–2006 (39 obs.):								
Average	−0.583	0.321	−0.511	0.718	−0.088	0.420	0.255	0.217
Standard deviation	0.007	0.005	0.006	0.004	0.008	0.006	0.013	0.006

TABLE 3 (*Continued*)

	u (v−c)	u (ch−c)	v (v−c)	v (ch−c)	b (v−c)	b (ch−v)	y (v−c)	y (ch−c)
2006–2007 (29 obs.):								
Average	−0.583	0.322	−0.513	0.714	−0.093	0.420	0.248	0.215
Standard deviation	0.007	0.006	0.007	0.007	0.006	0.008	0.006	0.008

of our first observation in observing season 9,

$$\text{HJD (phase zero)} = 2{,}451{,}086.90640 + (0.74552 \pm 0.00006)E.$$

Figure 1 shows the α Psc data plotted with this relation. The amplitudes for u, v, b, and y are 0.03, 0.005:, 0.02, and 0.015 mag, respectively. Some corrections have been applied to the plotted data, but not to those in Table 2, to bring results from different seasons into better agreement. Thus, for u the values for season 9 were increased by 0.003 mag and for y the values for season 9 were increased by 0.005 mag and those for season 11 were decreased by 0.005 mag. The b and y light curves appear to be in phase, but they are not quite in phase with u. We have not shifted the zero point, which is near the phase of light maximum, as this task requires better defined light curves. The differences in the light curves for u compared with those for b and y suggest a complex distribution of the elemental abundances. Before any attempt is made to do such modeling, the effects of the secondary must be removed. Some light curves in particular phase intervals show greater scatter about the mean light curve than at other phase intervals. More data are needed to clarify these observations.

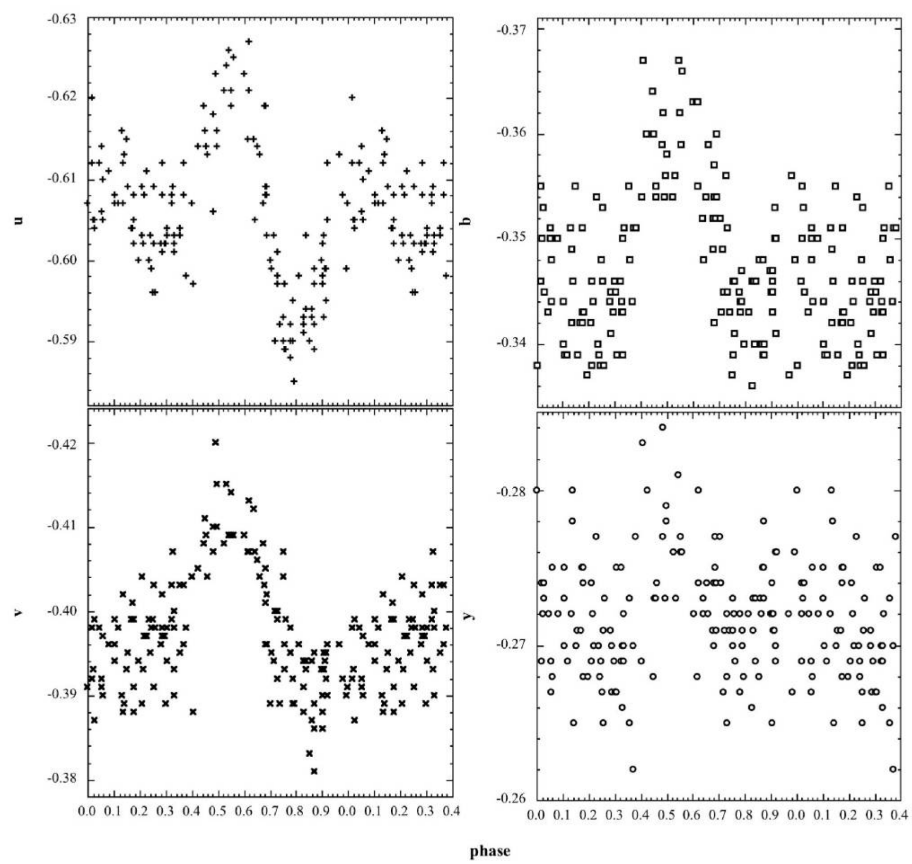

FIG. 2.—Differential FCAPT *uvby* photometry of HR 5857 according to the ephemeris of Hatzes (1990), HJD = 2,446,484.016 + 1.29557E. The light curves are roughly in phase, but the details seen in the u light curve become more difficult to see as the amplitude becomes smaller.

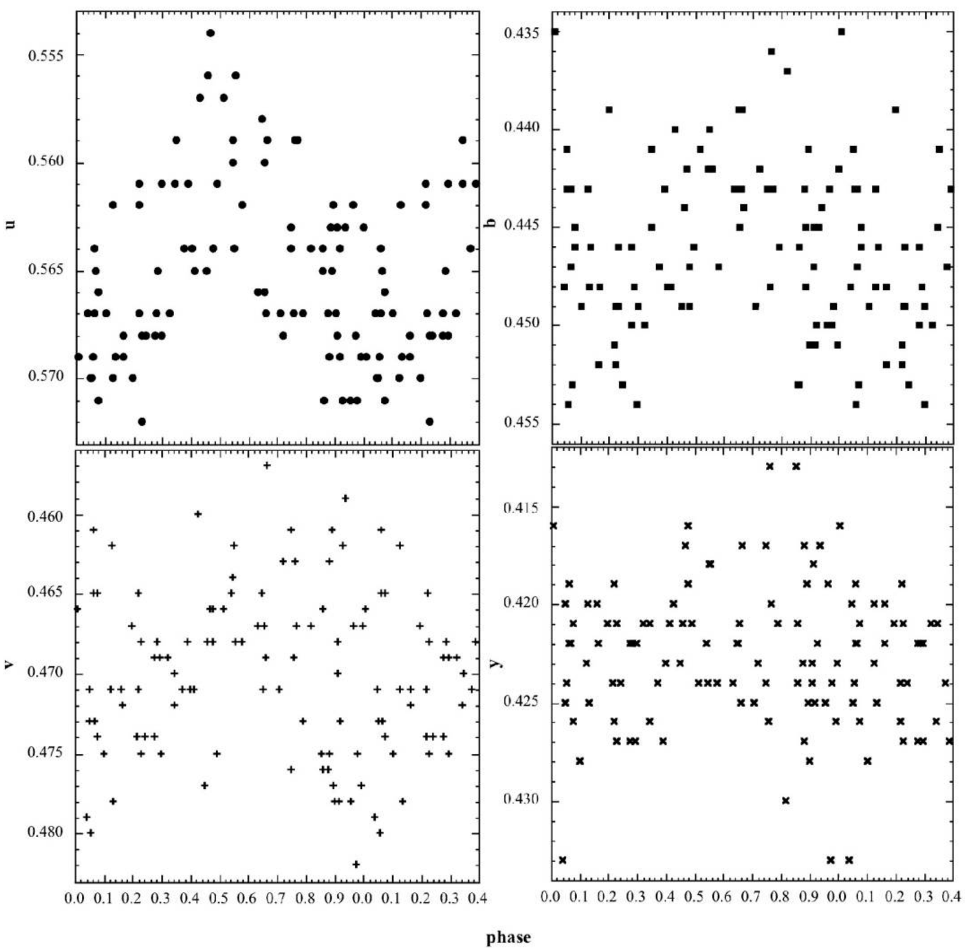

FIG. 3.—Differential FCAPT *uvby* photometry of HR 6709 relative to HD 163624 plotted according to the ephemeris HJD(u_{min}) = 2,450,520.096 ± 1.20352*E*. The variability of the *b*-values is offset by about 0.1 in phase relative to *u*. The *v*- and *y*-values are considered to be nonvariable.

2.2. HR 5857

HR 5857 (=HD 140728 = BP Boo) is a B9 pSiCr star. Photometry has been reported by Wehlau (1962), Blanco et al. (1973), and Winzer (1974). Forty-two, 23, 15, 20, and 36 good sets of *uvby* measures were obtained during observing seasons 6, 7, 8, 11, and 12, respectively. Using a Scargle periodogram a period of 1.8452 days was found, but the light curves had variable scatter about their means. We adopted instead the ephemeris of Hatzes (1990), HJD = 2,446,484.016 + 1.29557*E*. This period is also significant according to our Scargle periodogram but has a lesser S/N power. We did not adjust the zero point for easier comparison with Hatzes' silicon distribution. Hatzes found that the dipole nature of the assumed field is evident in the silicon distribution. Figure 2 shows that the light curves are roughly in phase with amplitudes of 0.035, 0.024, 0.021, and 0.012 mag for *u*, *v*, *b*, and *y*, respectively. Each has a light maximum and a light minimum per period. As the amplitude decreases it becomes more difficult to see the features of the *u* light curve. The phase difference between the primary and secondary minima in *u* and that between the meridional crossing of the two silicon spots is 0.44 (or 0.56).

2.3. HR 6709

Babcock (1958) considered HR 6709 (=HD 164258 = V2126 Oph) to be a suspected magnetic star. Renson & Manfroid (1980) found a period of 2.41 days, while Manfroid & Mathys (1985), employing a new photometric reduction of the same data (15 values), a period of 0.719 ± 0.005 days, which they note was in good agreement with its $v \sin i$ value (50 km s^{-1}; Abt & Morrell 1995). In the 1996–1997 and 1997–1998 observing seasons, 50 and 34 sets of good *uvby* FCAPT photometry, respectively, were obtained. The data studied were the values relative to HD 163624, which was used as the comparison star the first season and as the check star the second

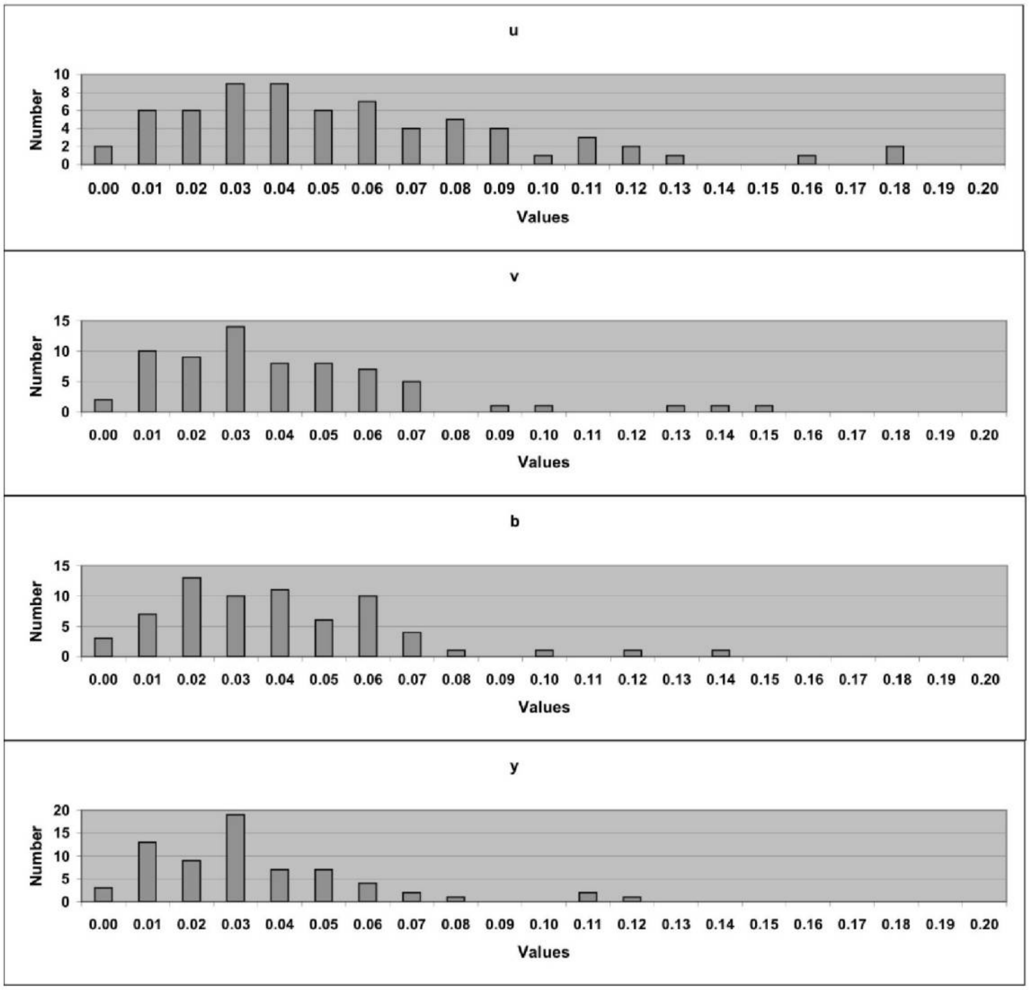

FIG. 4.—Histograms of the distributions of Strömgren *u, v, b, y* maximum amplitudes. The maximum amplitudes decrease as the filter central wavelengths increase. [*See the electronic edition of PASP for a color version of this figure.*]

season. Offsets in the mean values between the two years were checked and found to be significant only for *b*, in which case a 0.007 mag shift was applied to the data from observing season 8 (1997–1998) in the analysis (but not in Table 2). A change in comparison and check stars reduces their amplitudes of variations. Analyses of the *u* data, which has the largest standard deviation of the mean, with the Scargle periodogram and the CLEAN algorithm indicated a period of 1.20352 days, which is close to 1.205 days, one-half of the period of Renson & Manfroid (1980). The light curve shows a single wave variation. Our ephemeris is $\mathrm{HJD}(u_{\min}) = 2{,}450{,}520.096 \pm 0.001 + (1.20352 \pm 0.00005)E$. In Figure 3 the *u* data exhibit a single wave variability with an amplitude of about 0.010 mag. The maximum falls close to phase 0.5. The *v* and *y* data as functions of phase show scatter, with that for *y* being less than that for *v*. The *b* data vary with a single wave of amplitude of the order of 0.005 mag. Its maximum and minimum occur about 0.1 in phase later than those for *u*. The *u* and *b* data indicate that the surface distribution of magnetic fields and abundance anomalies must be complex. Our amplitudes tend to be less than those of Renson & Manfroid (1980).

3. THE CONSTANT OR NEARLY CONSTANT mCP STARS

In this series of photometric studies, three constant or nearly constant mCP stars were studied: HD 11187 (Adelman & Boyce 1995), HD 50169 (Adelman et al. 1998), and HD 204411 (Adelman 2003). HD 11187 was nonvariable for 3 yr, while HD 50169 was constant for 2 yr. Hensberge et al. (1981) re-

TABLE 4
MEAN *UVBY* AMPLITUDES AND STANDARD DEVIATIONS OF mCP STARS OBSERVED WITH THE FCAPT

HD	Star Name	*u*	*v*	*b*	*y*	Reference
11187	BD +54 393	0.000	0.000	0.000	0.000	1
12447	α Psc	0.030	0.005	0.020	0.015	2
14392	63 And	0.060	0.020	0.020	0.030	3
15144	AB Cet	0.004	0.005	0.014	0.013	2
15980	BD +39 571	0.020	0.016	0.023	0.021	2
16545	BD +43 551	0.050	0.060	0.060	0.035	4
19832	56 Ari	0.085	0.065	0.060	0.045	5
20629	BD +18 459	0.160	0.055	0.095	0.105	6
22316	HR 1094	0.015	0.007	0.015	0.010	7
22470	20 Eri	0.110	0.060	0.060	0.060	1
26571	HR 1297	0.035	0.030	0.035	0.025	8
27309	56 Tau	0.120	0.040	0.060	0.050	9
32633	HZ Aur	0.060	0.040	0.035	0.030	10
32650	HR 1643	0.110	0.050	0.045	0.045	11
32966	BD −14 1045	0.180	0.145	0.120	0.105	12
35298	BD +01 996	0.080	0.050	0.050	0.037	13
36668	BD +0 1113	0.050	0.035	0.030	0.025	14
37776	V901 Ori	0.030	0.040	0.035	0.035	15
40312	θ Aur	0.075	0.035	0.042	0.030	10
40394	36 Aur	0.055	0.020	0.025	0.025	16
43819	HR 2258	0.060	0.035	0.030	0.030	17
49333	12 CMa	0.065	0.045	0.040	0.035	18
50169	Brewer's	0.000	0.000	0.000	0.000	19
55579	HR 2722	0.045	0.013	0.013	0.010	16
62140	49 Cam	0.030	0.085	0.055	0.045	10
72968	3 Hya	0.030	0.022	0.024	0.024	10
74521	49 Cnc	0.025	0.015	0.035	0.025	20
79158	36 Lyn	0.035	0.025	0.015	0.010	14
81009	KU Hya	0.015	0.060	0.015	0.005	6
86592	BD −12 3045	0.040	0.130	0.040	0.018	14
90044	25 Sex	0.070	0.030	0.040	0.025	21
90569	45 Leo	0.040	0.010	0.005	0.003	6
93226	BD −09 3134	0.100	0.050	0.045	0.040	4
96707	HR 4330	0.010	0.010	0.020	0.025	22
111133	EP Vir	0.040	0.050	0.055	0.030	11
115708	HH Com	0.025	0.035	0.015	0.020	7
120198	84 UMa	0.035	0.015	0.020	0.010	23
126515	FF Vir	0.050	0.065	0.080	0.055	11
133029	BX Boo	0.020	0.025	0.025	0.020	20
140728	HR 5857	0.035	0.024	0.021	0.012	2
142070	BD −00 3026	0.020	0.025	0.005	0.010	24
152308	49 Her	0.055	0.028	0.035	0.023	22
164258	HR 6709	0.010	0.005	0.005	0.000	2
164429	HR 6718	0.045	0.015	0.010	0.010	22
170973	HR 6958	0.030	0.020	0.020	0.015	15
171247	HR 6967	0.075	0.050	0.045	0.035	23
171782	BD +05 3816	0.090	0.055	0.070	0.070	12
177410	HR 7224	0.060	0.045	0.035	0.030	21
179527	19 Lyr	0.045	0.025	0.030	0.025	13
184905	BD +43 3290	0.105	0.025	0.045	0.045	11
188041	HR 7575	0.010	0.100	0.00:	0.010	4
192678	BD +53 2368	0.014	0.011	0.005	0.005	6
192913	MW Vul	0.085	0.055	0.070	0.075	17
193722	HR 7786	0.130	0.065	0.065	0.065	19
197018	HR 7911	0.030	0.022	0.020	0.018	12
200311	BD +43 3786	0.035	0.030	0.030	0.025	21
204131	HR 8206	0.035	0.005:	0.010	0.005	4
204411	HR 8216	0.006	0.004	0.016	0.010	16
205087	HR 8240	0.005	0.010	0.055	0.020	2
210071	HR 8434	0.065	0.060	0.060	0.045	24
215441	Babcock's	0.180	0.140	0.140	0.120	9

TABLE 4 (*Continued*)

HD	Star Name	u	v	b	y	Reference
217833	HR 8770	0.120	0.070	0.070	0.055	16
219749	HR 8861	0.080	0.025	0.025	0.025	14
220147	BD +61 2430	0.090	0.030	0.060	0.060	25
220885	HR 8913	0.070	0.045	0.040	0.030	25
221394	HR 8933	0.080	0.040	0.040	0.035	1
223358	HR 9017	0.025	0.010	0.010	0.010	17
226340	108 Aqr	0.060	0.070	0.067	0.045	3
Average		0.055	0.039	0.038	0.031	
Standard deviation		0.041	0.031	0.027	0.024	

REFERENCES.—(1) Adelman & Boyce 1995; (2) this paper; (3) Adelman & Knox 1994; (4) Adelman 2007; (5) Adelman & Freid 1993; (6) Adelman 2006; (7) Adelman 1999; (8) Adelman & Brunhouse 1998; (9) North & Adelman 1995; (10) Adelman & Kaewkornmaung 2005; (11) Adelman & Sutton 2007; (12) Adelman & Meadows 2002; (13) Adelman & Rice 1999; (14) Adelman 2000a; (15) Adelman 1997b; (16) Adelman 2003; (17) Adelman & Young 2005; (18) Adelman 2000b; (19) Adelman et al. 1998; (20) Adelman 1998; (21) Adelman 1997a; (22) Adelman et al. 1999; (23) Wade et al. 1998; (24) Adelman 2001; (25) Adelman 2005.

ported that it was constant for a longer period. It is still a good idea to get new observations to check for any long-term variability of either star. For HD 204411 FCAPT observations from seasons 1 through 13 are published and show changes in its *b*- and *y*-values by 0.016 and 0.010 mag, respectively. Observations have continued since then. For AB Cet, HD 15980, and HR 8240 there are three or more seasons with data to supplement published FCAPT values.

3.1. AB Cet

Adelman & Boyce (1995) studied three observing seasons (1, 4, and 5 with a total of 75 observations) of *uvby* photometry of AB Cet (=HD 15144 = HR 710). They found that their comparison star HD 14940 was variable, but the check star HD 15130 and AB Cet were much less so. Season 6 (1995–1996; seven observations) has averages close to those of previous seasons. However, without a stable comparison star, it is difficult to determine whether changes of the order of 0.01 mag have occurred due to a variety of possible causes. For seasons 9 (1998–1999), 14 (2003–2004), and 16 (2005–2006), HD 15130 is the comparison star and π Cet the check star. Unfortunately, the neutral density filters were changed between seasons 6 and 9 and seasons 9 and 14, sometime between 1996 and 2004. The results of seasons 14 and 16 are not as close as might be expected for a constant star. To solve these difficulties more photometry is needed with 40 or more good observations per season using the current neutral density filters. AB Cet is probably a nearly constant star.

3.2. HD 15980

Adelman (1999) obtained 13, 34, and 48 sets of *uvby* observations in observing seasons 6, 7, and 8. On the basis mainly of a change in the mean *u*-values by 0.022 mag, he concluded that HD 15980 was a long-period variable mCP star. Between these observations and additional observations in seasons 14, 15, 16, and 17, there was a change in neutral density filter for the check star. Furthermore, there was an unexpected change of the order of 0.025 mag in the v−c values, which indicates variability. Furthermore, a similar change in the mean *u*-values (but in the reverse manner) among the new observations of HD 15980 occurs. The period is probably at least 5 yr long. To confirm these changes, additional observations of HD 15980 are required.

3.3. HR 8240

Adelman & Knox (1994) studied 37 sets of *uvby* photometry taken during the first three observing seasons. The standard deviations of the means for the four v−c values were similar to those for the respective ch−c data. There were also seven scattered observations for season 4, five for season 5, 39 for season 16, and 29 for season 17. The means and the standard deviations of the means for each set are given in Table 3. As no neutral density filters are used, we infer that the amplitudes are around 0.005, 0.010, 0.055, and 0.020 mag in *u*, *v*, *b*, and *y*, respectively. However, if we examine v−ch values, then the respective amplitudes would be 0.011, 0.006, 0.007, and 0.011 mag, which on the whole are smaller. It is desirable that additional seasons of photometry with at least 30 good observations take place to better define our knowledge of HR 8240's behavior. Even so, HR 8240 is variable.

4. THE DISTRIBUTION OF AMPLITUDES FOR STRÖMGREN *uvby*

We assembled the *uvby* amplitudes of all of the mCP stars by the first author to better characterize the mCP star variability as a class. We now present the histograms of these distributions in Figure 4. Our bins are spaced 0.01 mag wide and include values between +0.004 and −0.005 mag of the central values. The *u*, *b*, *v*, and *y* histograms look in general similar to one another, especially after allowing for the differences in their means. Table 4 lists the amplitudes by star for each of the Strömgren magnitudes and gives the references. The means of these distributions are 0.055 ± 0.041 mag for u, 0.039 ± 0.031 mag for v, 0.038 ± 0.027 mag for b, and 0.031 ± 0.024 mag for y. Thus, the mean amplitudes and their standard deviations of the mean decrease with increasing wavelength.

5. COMMENTS

AB Cet, HR 15980, and HR 8240 are at least slightly variable, and HD 11187 and HD 50169 have been constant for two and three observing seasons. Additional confirmation observations are desired. The mCP stars are known to rotate more slowly than the corresponding normal stars. Two of 68 seeming constant is not inconsistent with all mCP stars being variable and having a random distribution of their rotational axes (Abt 2001).

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Facilities: DAO:1.22m

APPENDIX

SCARGLE PERIODOGRAMS AND INFORMATION FOR α Psc, HR 5857, AND HR 6709

This Appendix contains Figures 5, 6, and 7, which show the Scargle periodograms of α Psc, HR 5857, and HR 6709, respectively. They were produced from a slight modification of A. Fullerton's 1986 implementation in IDL of the Scargle periodogram. Table 5 gives information on each of these, including the period adopted in days, the name of the filter, the number of values, the power S/N at the 1% level of statistical significance, and the power S/N value for the adopted period. Some other useful information is given in the sections discussing the period determinations of each of these stars. The period for α Psc is the unmodified value from its Scargle periodogram, while those of the other two stars considered are also values from the previous studies.

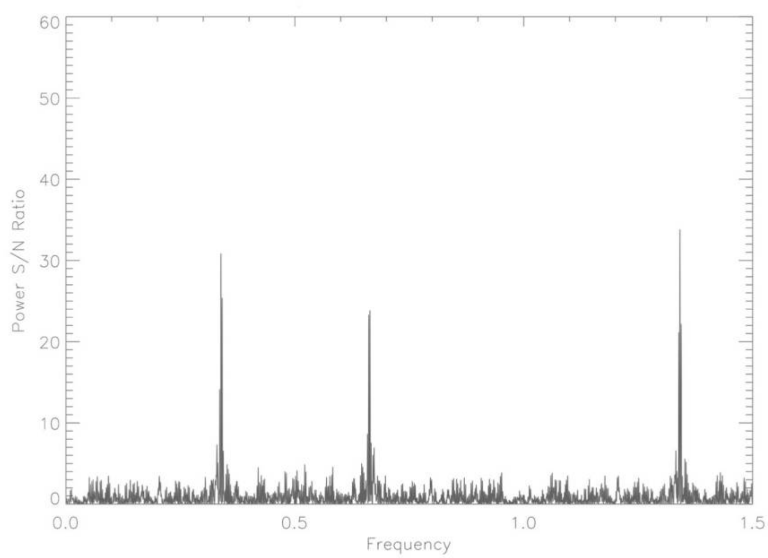

FIG. 5.—Scargle peroidogram of the u observations of α Psc, whose period is 0.74452 days.

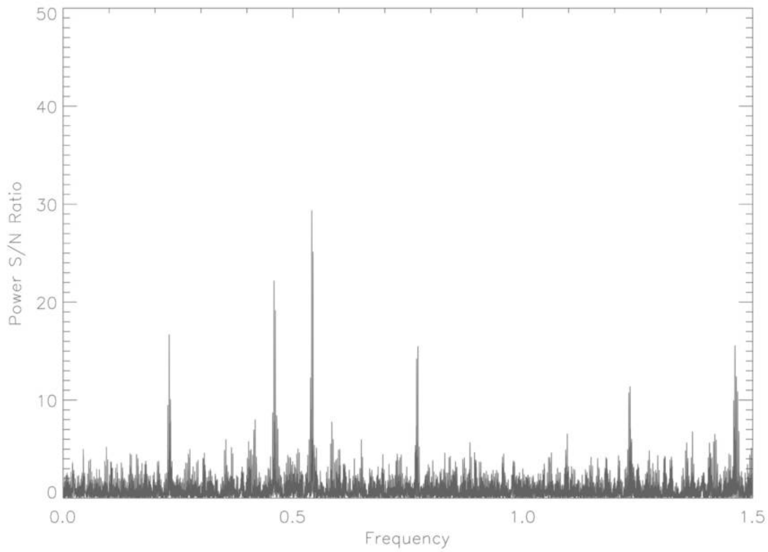

FIG. 6.—Scargle peroidogram of the *u* observations of HR 5857, whose frequency with the maximum power S/N corresponds to 1.8452 days. However, we adopted the Hatzes (1990) period of 1.29557 days, as the former period shows scatter with a variable amplitude.

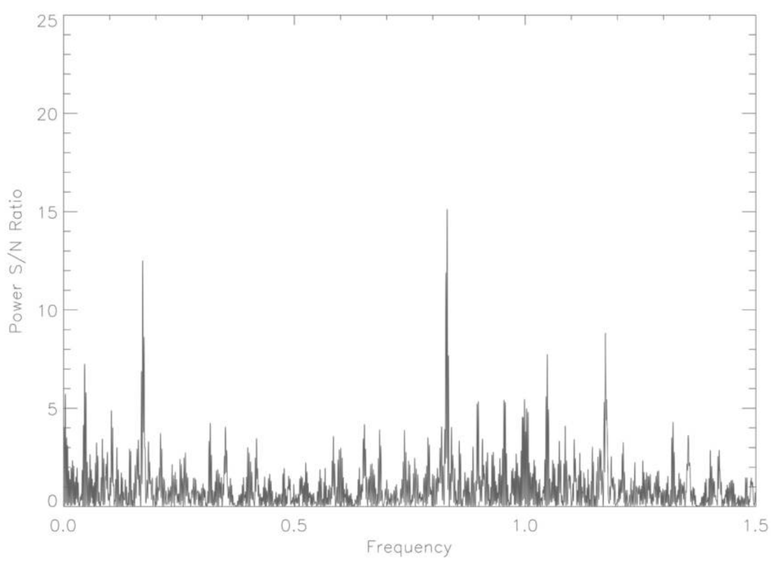

FIG. 7.—Scargle peroidogram of the *u* observations of HR 6709, whose maximum frequency corresponds to 1.20352 days.

TABLE 5
PERIODOGRAM INFORMATION

Star Name	Period (days)	Filter	Values	Power S/N at 1%	Power S/N at Period
α Psc	0.74552	*u*	106	14.2159	33.8092
HR 5857	1.29957	*u*	152	14.2159	15.5013
HR 6709	1.20352	*u*	90	14.2159	15.0229

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