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ESTABLISHING OBSERVATIONAL BASELINES FOR TWO δ SCUTI VARIABLES: V966 HERCULIS AND V1438 AQUILAE

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ABSTRACT

We have examined the previously understudied δ Scuti stars V966 Herculis and V1438 Aquilae. We find that V966 Her is a stable pulsator with a refined period of 0.1330302 days with a full V amplitude of 0.096 mag. We also find that V966 Her has an average radial velocity of +7.8 km s^{-1}, a full radial velocity amplitude of 7.6 km s^{-1}, and a $v \sin i = 63.8$ km s^{-1}. For V1438 Aql we report a revised *Hipparcos* period of 0.1612751 days with a full amplitude of 0.056. The average radial velocity is found to be -43 km s^{-1}, with full amplitude of 9.7 km s^{-1}, and a $v \sin i = 76.7$ km s^{-1}. Due to some anomalies seen in V1438 Aql we feel that a much larger photometric and spectroscopic campaign is required to determine the true nature of this star.

Key words: δ Scuti — stars: individual (V1438 Aquilae, V966 Herculis)

Online material: machine-readable tables

1. INTRODUCTION

The stars V966 Herculis and V1438 Aquilae are both lower amplitude δ Scutis with full amplitudes of 0.10 and 0.07 mag, respectively. Previous studies of other low- to medium-amplitude δ Scuti variables have shown dynamic variations in period and amplitude. V1162 Ori has shown period and amplitude variations over many years (Hintz et al. 1998; Arentoft et al. 2001; Civelek et al. 2003). A recent study of AN Lyn by Hintz et al. (2005) showed amplitude variations that appeared to be in sync with an orbital motion. With the tendency of these stars to exhibit interesting period and amplitude variations we have chosen to examine V966 Her and V1438 Aql to establish baselines for future monitoring. Neither star has received a great deal of attention, but both are relatively bright stars with a variety of published data.

V966 Her (HD 161287, HIP 86711; $\alpha_{J2000.0} = 17^h43^m03^s.47$, $\delta_{J2000.0} = +37°34'11''$, $\langle V \rangle = 8.11$) was found to be variable by *Hipparcos*. Van Leeuwen (1997) gave a period of 0.133029 ± 0.000003 days and an amplitude of 0.10 mag, and a parallax of $\pi = 4.48 \pm 0.68$ was reported by Perryman et al. (1997), which corresponds to a distance of 223 ± 29 pc. Finally, Grenier et al. (1999) found a radial velocity of -1.8 ± 4.4 km s^{-1}. V966 Her has published Strömgren indices (Olsen 1983), but it does not have a published Hβ value.

The variability of V1438 Aql (HD 176445, HIP 93259; $\alpha_{J2000.0} = 18^h59^m50^s.97$, $\delta_{J2000.0} = +11°26'42''$, $\langle V \rangle = 7.80$) was also discovered by *Hipparcos*. A period of 0.161272 ± 0.000013 days and an amplitude of 0.07 mag were given by van Leeuwen (1997). *Hipparcos* also provided a parallax of $\pi = 3.41 \pm 0.98$ (Perryman et al. 1997), which corresponds to a distance of 293 ± 65 pc. From Strömgren indices Olsen (1980) estimated the star to be a reddened A9. In Olsen (1994) the full Strömgren indices are given as $(b - y) = 0.280$, $m_1 = 0.149$, $c_1 = 0.854$, and H$\beta = 2.726$.

2. PHOTOMETRIC AND SPECTROSCOPIC OBSERVATIONS

Photometric observations of the two stars were secured between 1999 June and 2005 September. A total of 13 nights of data were obtained for V966 Her and 11 nights for V1438 Aql. All photometric data were obtained using the 0.4 m David Derrick Telescope (DDT) of Brigham Young University's Orson Pratt Observatory (Provo, Utah). A variety of telescope focus/CCD combinations were used throughout the course of the observations. A summary of these configurations is given in Table 1. All observations of V966 Her were obtained through a standard Johnson V filter. The majority of the V1438 Aql nights were taken with a set of Johnson BVR filters. All observations were reduced using standard IRAF procedures.

Spectroscopic data were secured between 2002 June and 2004 August at the Dominion Astrophysical Observatory (DAO). All observations were obtained using the 1.2 m McKellar Telescope with the coudé spectrograph using the 32121 grating. The grating is blazed at 5000 Å and yields 10.1 Å mm^{-1}. Using the Site4 CCD with 15 μm pixels gives 0.15 Å pixel^{-1}. On separate runs the spectrograph was set to observe in the region of Hβ or the region from Ca II H and K to Hγ. All spectra were processed with the DOSLIT package in IRAF with wavelength calibration being done with a FeAr comparison arc. In addition, a number of radial velocities were measured with the Radial Velocity Speedometer (RVS) on the DAO 1.2 m telescope in 2001 March.

3. SPECTROSCOPIC AND PHOTOMETRIC ANALYSES

3.1. *Spectrophotometry and Metal Estimates*

Earlier we stated that no Strömgren Hβ measurement had been published for V966 Her. Using our spectra that covered the Hβ

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TABLE 1
DDT Telescope and CCD Specifications

Focus	CCD	Pixel Size (μm)	Plate Scale (arcsec pixel^{-1})	Array Size (pixels)	Years
Cassegrain	Apogee Ap8p	24	0.76	1024 × 1024	2001–2002
Newtonian	Apogee Ap47p	13	1.32	1024 × 1024	2004
Newtonian	Meade Pictor 416	9	0.91	768 × 512	1999–2001
Newtonian	Meade Pictor 1616	9	0.91	1536 × 1024	1999–2003
Cassegrain	SBIG ST-1001	24	0.76	1024 × 1024	2005

region we calibrate a spectrophotometric measurement of the index from five stars with known indices. This gives a value of $H\beta = 2.733 \pm 0.011$. Using the calibrations in Crawford (1975, 1979) and the published Strömgren data we find a color excess of $E(b - y) = 0.006 \pm 0.011$, or effectively no reddening. Also using this calibration we estimate the absolute magnitude to be $M_V = 1.63 \pm 0.19$, which gives a distance of 200 ± 30 pc. This is in agreement with the *Hipparcos* measurement mentioned earlier. Finally, we use the equations in McNamara & Powell (1985) to find a metal estimate of $[\mathrm{Fe/H}] = -0.05 \pm 0.03$, or very near solar.

For V1438 Aql we use the Strömgren data mentioned earlier and the calibrations in Crawford (1975, 1979). From these we find a color excess of $E(b - y) = 0.084 \pm 0.009$ and an absolute magnitude estimate of $M_V = 0.74 \pm 0.08$. This gives a distance of 219 ± 20 pc. Again using the relations from McNamara & Powell (1985), we estimate a metallicity of $[\mathrm{Fe/H}] = -0.35 \pm 0.13$. However, we must note that V1438 Aql is slightly outside the color range given in McNamara & Powell (1985).

3.2. *Radial Velocities and Rotational Velocities*

For V966 Her we obtained 78 radial velocities with the RVS system at DAO. These velocities were calibrated against five radial velocity standards: HD 89449, HD 102870, HD 122693, HD 136202, and HD 149803. The mean residual for all standard star measurements was 0.6 km s^{-1}. From spectral data we obtained 16 radial velocity measurements using the IRAF function RVIDLINES. These observations were zero-point-corrected using

TABLE 2
Radial Velocity Measurements for V966 Herculis

HJD 2,450,000.0+	RV (km s^{-1})	Instrument	HJD 2,450,000.0+	RV (km s^{-1})	Instrument	HJD 2,450,000.0+	RV (km s^{-1})	Instrument
2021.9131	+4.5	RVS	2031.8313	+10.7	RVS	2036.8408	+10.0	RVS
2021.9206	+6.5	RVS	2031.8388	+6.5	RVS	2036.8443	+12.0	RVS
2021.9282	+8.3	RVS	2031.8434	+6.9	RVS	2036.8481	+10.8	RVS
2021.9374	+9.3	RVS	2031.8478	+4.2	RVS	2036.8529	+11.5	RVS
2021.9452	+11.3	RVS	2031.8533	+6.3	RVS	2036.8570	+12.8	RVS
2021.9533	+11.6	RVS	2031.8576	+4.2	RVS	2036.8616	+12.8	RVS
2024.8675	+12.0	RVS	2031.8622	+5.0	RVS	2036.8647	+11.6	RVS
2025.8448	+6.6	RVS	2031.8665	+4.7	RVS	2036.8688	+12.2	RVS
2025.8484	+7.4	RVS	2031.8721	+5.0	RVS	2036.8735	+12.2	RVS
2025.8524	+5.1	RVS	2031.8762	+6.5	RVS	2036.8792	+10.2	RVS
2025.8582	+4.3	RVS	2031.8822	+7.5	RVS	2036.8830	+8.7	RVS
2025.8628	+3.5	RVS	2031.8888	+7.3	RVS	2036.8869	+8.2	RVS
2025.8673	+2.9	RVS	2031.8947	+10.6	RVS	2340.0432	+11.7	CCD
2025.8715	+2.6	RVS	2034.7677	+6.1	RVS	2340.0542	+11.0	CCD
2025.8878	+3.8	RVS	2034.7722	+5.8	RVS	2340.0652	+8.3	CCD
2025.8920	+4.8	RVS	2034.7764	+6.6	RVS	2496.7260	+10.1	CCD
2025.8958	+6.1	RVS	2034.7801	+4.2	RVS	2496.7353	+11.8	CCD
2025.9001	+6.4	RVS	2034.7851	+3.8	RVS	2693.0325	+2.8	CCD
2025.9044	+7.3	RVS	2034.7851	+4.1	RVS	2693.0435	+6.3	CCD
2025.9102	+8.9	RVS	2034.7902	+3.6	RVS	2698.0375	+10.9	CCD
2025.9145	+7.7	RVS	2034.7951	+7.2	RVS	2698.0469	+7.7	CCD
2025.9184	+9.1	RVS	2034.7996	+2.3	RVS	2698.0562	+6.5	CCD
2025.9228	+9.9	RVS	2034.8042	+3.9	RVS	2698.0703	+3.3	CCD
2025.9280	+9.7	RVS	2034.8074	+4.7	RVS	2899.6299	+3.3	CCD
2025.9346	+10.7	RVS	2034.8108	+4.9	RVS	2899.6407	+4.1	CCD
2025.9392	+9.3	RVS	2034.8150	+6.1	RVS	2899.6516	+6.2	CCD
2025.9441	+10.1	RVS	2036.8151	+7.0	RVS	2899.6642	+7.4	CCD
2025.9486	+10.1	RVS	2036.8187	+6.8	RVS	2899.6751	+9.4	CCD
2025.9532	+10.8	RVS	2036.8229	+9.0	RVS			
2025.9592	+11.4	RVS	2036.8261	+8.5	RVS			
2025.9689	+10.4	RVS	2036.8300	+7.6	RVS			
2025.9744	+8.2	RVS	2036.8332	+9.9	RVS			
2025.9796	+7.4	RVS	2036.8373	+11.6	RVS			

Note.—Table 2 is also available in machine-readable form in the electronic edition of the *Astronomical Journal*.

TABLE 3
RADIAL VELOCITY MEASUREMENTS FOR V1438 AQUILAE

HJD 2,450,000.0+	RV (km s^{-1})	Instrument	HJD 2,450,000.0+	RV (km s^{-1})	Instrument	HJD 2,450,000.0+	RV (km s^{-1})	Instrument
2432.8429	−43.1	CCD	3231.7426	−42.5	CCD	3233.8055	−39.7	CCD
2432.8555	−40.0	CCD	3231.7524	−43.2	CCD	3233.8173	−41.3	CCD
2498.6954	−43.0	CCD	3231.7681	−43.0	CCD	3233.8284	−44.3	CCD
2498.7039	−44.7	CCD	3231.7792	−41.4	CCD	3235.7267	−36.5	CCD
2498.7123	−45.5	CCD	3233.7103	−42.2	CCD	3235.7382	−39.0	CCD
2498.7207	−47.2	CCD	3233.7221	−40.9	CCD	3235.7491	−41.5	CCD
2498.7305	−47.0	CCD	3233.7375	−38.3	CCD	3235.7621	−43.1	CCD
2498.7394	−46.8	CCD	3233.7493	−35.6	CCD	3235.7729	−43.7	CCD
2498.7482	−46.0	CCD	3233.7604	−34.7	CCD	3235.7838	−44.4	CCD
2498.7575	−46.0	CCD	3233.7715	−35.6	CCD	3235.7956	−43.2	CCD
2498.7673	−43.6	CCD	3233.7832	−36.6	CCD	3235.8064	−42.4	CCD
3231.7364	−43.3	CCD	3233.7943	−38.3	CCD	3235.8173	−39.5	CCD

NOTE.—Table 3 is also available in machine-readable form in the electronic edition of the *Astronomical Journal*.

four standards: o Aql, ι Psc, 5 Ser, and β Vir. The residuals for the radial velocities determined from spectra were about 0.7 km s^{-1} for the standard stars, and we estimated about 0.7–0.9 km s^{-1} for observations of V966 Her. All radial velocities for V966 Her are found in Table 2. From our data we find an average radial velocity of +7.8 km s^{-1} and a full amplitude of 7.6 km s^{-1}. This value is clearly different than the -1.8 ± 4.4 km s^{-1} reported by Grenier et al. (1999).

For V1438 Aql we found 36 radial velocities from spectral data, 11 from the spectral region of Hβ, and 25 from the spectral region of Ca II H and K. These were zero-pointed using the same set of standards detailed above with the same error ranges. We collect all radial velocities for V1438 Aql in Table 3. The average value is approximately -43 km s^{-1} with a full amplitude of 9.7 km s^{-1}. However, there is a definite shift between the 2002 and 2004 data of about 2.5 km s^{-1} that cannot be fully explained by the errors. This kind of shift might be expected from a binary system, but with only two seasons of well-separated data there is insufficient information to draw this conclusion. The radial velocities for V1438 Aql are discussed further in § 3.4.

Finally, measuring the FWHM of a number of metal features in the region of 4500 Å, we used the equations in Fekel (2003) to determine rotational velocities for both stars. For V1438 Aql we found an average rotational velocity of 76.7 ± 3.9 km s^{-1}. For V966 Her we found an average rotational rate of 63.8 ± 2.5 km s^{-1}. Both of these values are consistent with rotational rates for medium- to low-amplitude δ Scuti stars. However, we must note that the relations in Fekel (2003) only considered stars with rotational velocities less than 60 km s^{-1}.

3.3. *Spectral Types*

In the examination of the spectral type of these two stars we started by merging our two spectral regions into one continuous spectrum. These spectra were digitally compared to the archive

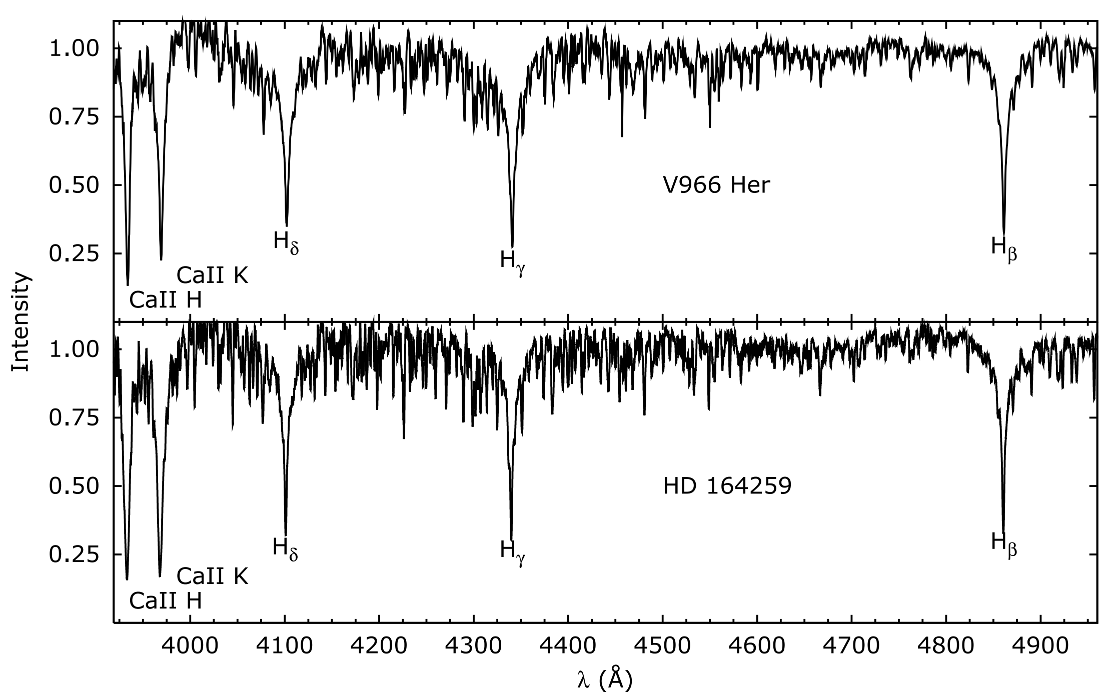

FIG. 1.—Continuum-corrected spectra of V966 Her and HD 164259 from Ca II H and K to Hβ. The major features are labeled.

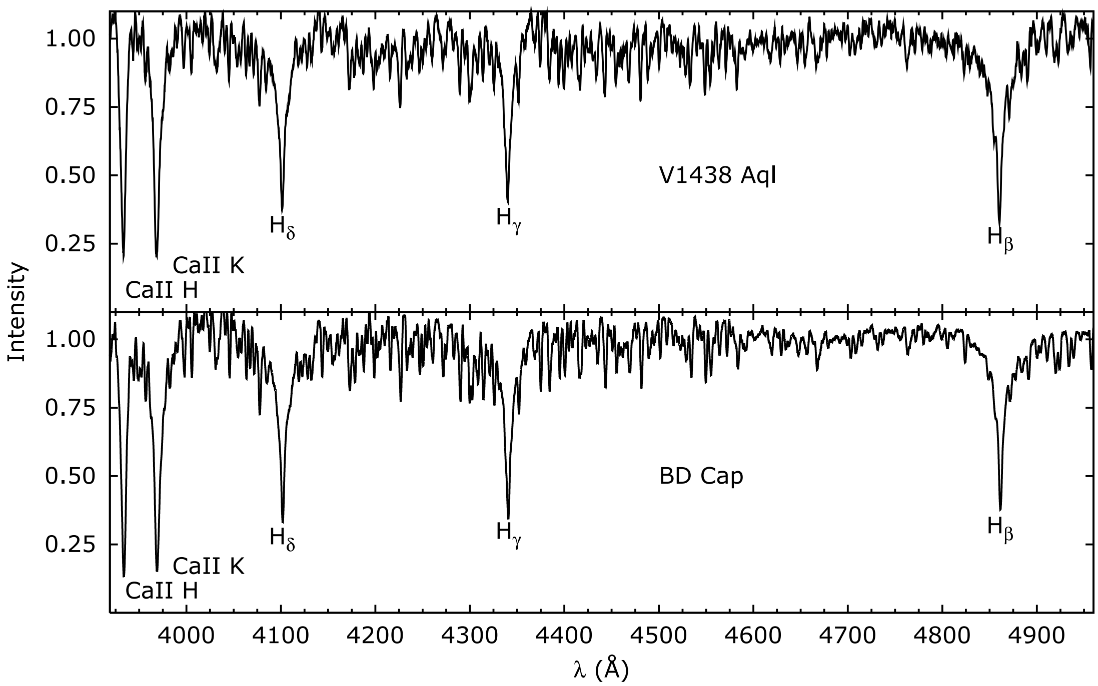

FIG. 2.—Continuum-corrected spectra of V1438 Aql and BD Cap from Ca II H and K to Hβ. The major features are labeled.

of spectra detailed by Bagnulo et al. (2003). From this comparison we found that the closest match for V966 Her was an F2 V. Our full spectra from Ca II H and K to Hβ for V966 Her is shown in Figure 1 along with the spectra of HD 164259 (Bagnulo et al. 2003). HD 164259 was selected for display because it is the closest spectral type, F2 IV, with a published [Fe/H] value of -0.15 (Nordström et al. 2004). From a visual inspection we feel that the value derived from the Strömgen indices of about [Fe/H] $= -0.05 \pm 0.03$ is reasonable for V966 Her.

For V1428 Aql we have once again digitally compared our spectra to archival spectra from Bagnulo et al. (2003) and found that the best match gives a spectral type of A9 IV–V. In Figure 2 we compare the spectra of V1438 Aql and BD Cap (Bagnulo et al. 2003). BD Cap is classified as A9 III by Bagnulo et al. (2003) with a metal content of [Fe/H] $= -0.03$ (Nordström et al. 2004). Again, BD Cap was selected because it was the closest spectral type with a published metal estimate.

3.4. *Photometry*

The observed fields for both stars provide a selection of comparison stars for differential photometry, although both stars are by far the brightest in each field. In Figure 3 we show the field around V966 Her with the comparison labeled. For V1438 Aql we show the field and comparison stars in Figure 4. An ensemble of the comparison stars was selected and used to obtain differential

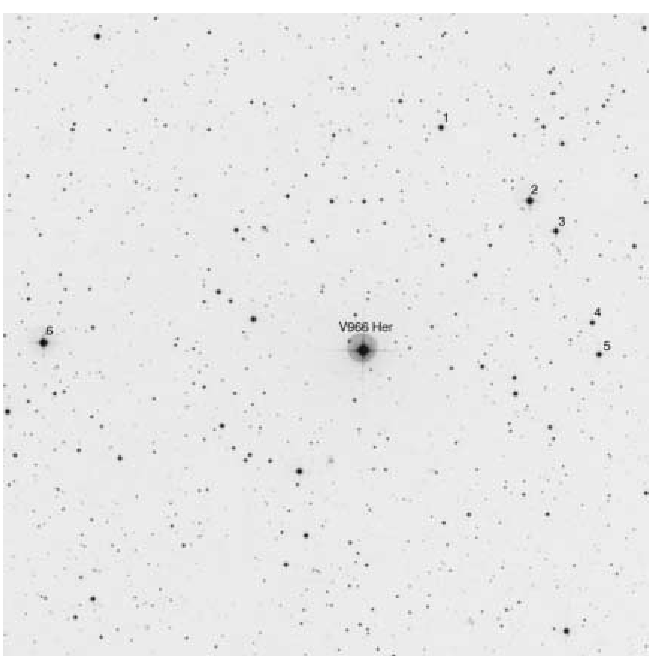

FIG. 3.—Field around V966 Her, with the comparison stars labeled.

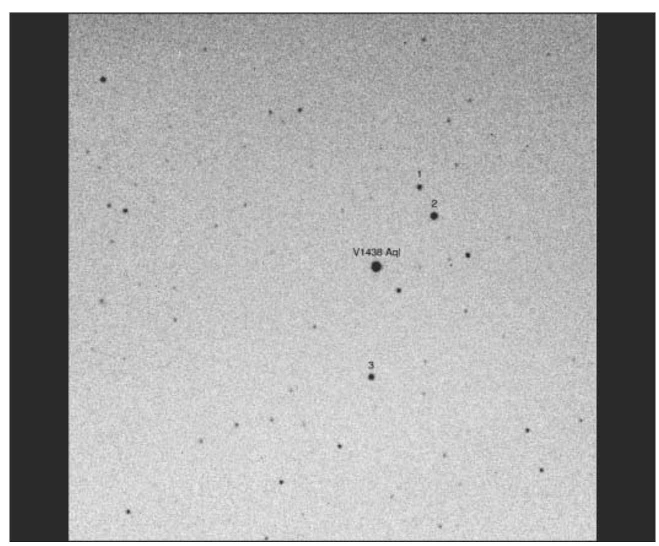

FIG. 4.—Field around V1438 Aql, with the comparison stars labeled.

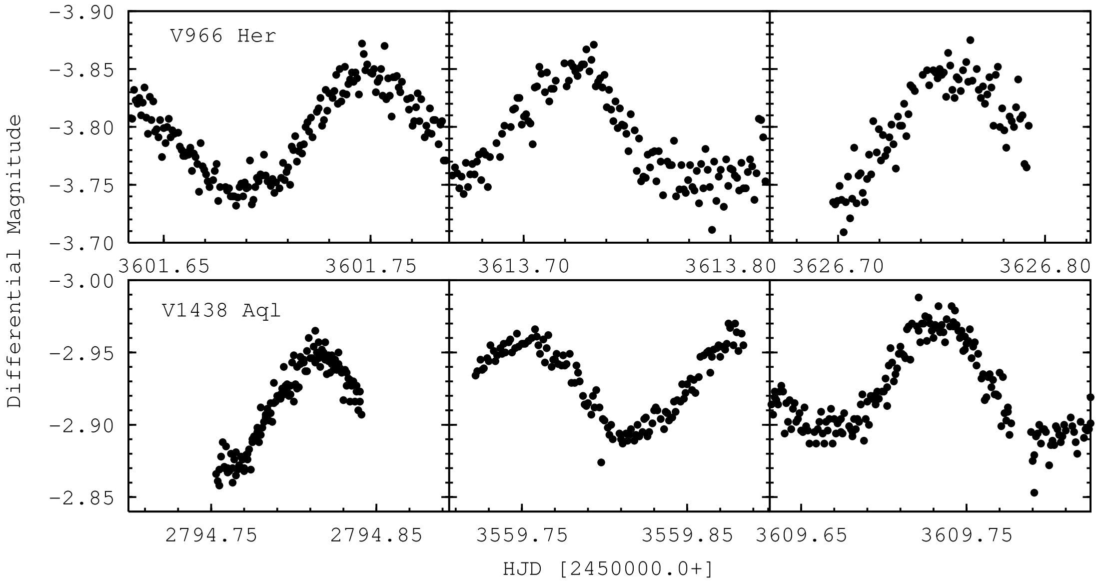

FIG. 5.—Representative light curves for V966 Her and V1438 Aql on three nights.

magnitudes on each night using the methods detailed in Hintz et al. (1997). Sample light curves for both stars are shown in Figure 5. The light curves of V966 Her show a fairly repeatable shape, with minor cycle-to-cycle variation. An examination of the light curves of V1438 Aql shows stronger cycle-to-cycle variations.

3.4.1. *V966 Herculis*

The published *Hipparcos* period for V966 Her is 0.133029 days. From our light curves we found 13 times of maximum light using a parabolic fit. All times are gathered in Table 4. From these maxima we determined a revised period as given in equation (1), with a full amplitude of 0.096 mag. Our solution is in excellent agreement with the period from *Hipparcos*:

$$\mathrm{HJD}_{\max} = 2,452,051.8156(7) + 0.1330302(1)E. \qquad (1)$$

Using the period in equation (1) we phased both the 2005 *V* photometry and all radial velocity measurements. The results are shown in Figure 6. This shows the stability of V966 Her over the years of the study. Although it is difficult to see in the phased light curve, there is a sharper rise than decline. The inverse of this is more visible in the radial velocity curve. This mirror image confirms the pulsational nature of V966 Her.

From a Period04 (Lenz & Breger 2005) analysis of the entire data set we find a primary frequency of 7.5172 cycles day^{-1}. In addition, we have data sets in 2001 and 2005 with sufficient coverage to run independent analyses. For these two seasons we find primary frequencies of 7.5166 and 7.5167 cycles day^{-1}, respectively, with a constant amplitude of 0.048 mag. All indications are that V966 Her has a constant primary period and amplitude. However, the shape of the light curve has small cycle-to-cycle variations, which indicates the presence of at least one additional frequency. Unfortunately, our data set is insufficient to find this second frequency.

TABLE 4
TIMES OF MAXIMUM LIGHT FOR V966 HERCULIS

HJD 2,450,000.0+	Cycle	$(O-C)$
2051.8137	0	−0.0019
2051.9483	1	−0.0001
2061.9262	76	0.0005
2065.9200	106	0.0034
2079.8835	211	−0.0013
2082.8138	233	0.0024
2082.9421	234	−0.0024
2436.8058	2894	0.0010
2886.7139	6276	0.0010
3601.7530	11651	0.0027
3602.8161	11659	0.0016
3613.7227	11741	−0.0003
3626.7581	11839	−0.0018

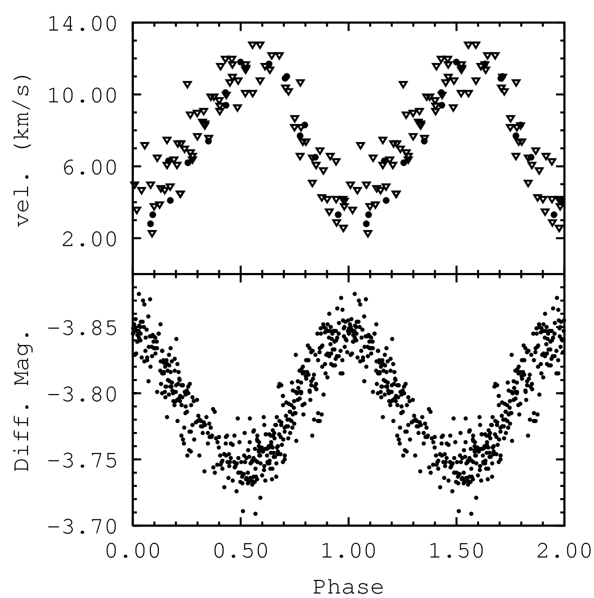

FIG. 6.—Phased radial velocity curve and differential light curve for V966 Her. For radial velocities RVS data are shown as triangles, and radial velocities from spectra are shown as circles.

TABLE 5
TIMES OF MAXIMUM LIGHT FOR V1438 AQUILAE

HJD 2,450,000.0+	Filter	Cycle[a]	$(O - C)$[a]	Cycle[b]	$(O - C)$[b]
2520.8108	*B*	0	0.0027	0	0.0027
2520.8094	*V*	0	0.0013	0	0.0013
2520.8145	*R*	0	0.0064	0	0.0064
2536.7707	*B*	115	0.0001	99	−0.0036
2536.7682	*V*	115	−0.0024	99	−0.0061
2536.7705	*R*	115	−0.0001	99	−0.0038
2538.7164	*B*	129	0.0025	111	0.0068
2538.7109	*V*	129	−0.0030	111	0.0013
2538.7079	*R*	129	−0.0060	111	−0.0017
2779.8106	*B*	1866	−0.0063	1606	−0.0053
2794.8147	*V*	1974	0.0069	1699	0.0002
3559.7521	*B*	7485	−0.0062	6442	0.0098
3559.7513	*V*	7485	−0.0070	6442	0.0090
3609.7321	*B*	7845	0.0043	6752	−0.0055
3609.7324	*V*	7845	0.0046	6752	−0.0052
3609.7322	*R*	7845	0.0044	6752	−0.0054

[a] Period = 0.1388043 days.
[b] Period = 0.1612751 days.

3.4.2. *V1438 Aquilae*

From our data we determined 16 times of maximum light from three different filters, again using a parabolic fit to each maxima. These times are collected in Table 5. We began our analysis using the published *Hipparcos* period of 0.161272 days for V1438 Aql, or a frequency of 6.2007 cycles day^{-1}. This gave the ephemeris given in equation (2) with a full amplitude of 0.056 mag. However, this solution had relatively large residuals. Therefore, we began a search for a new period using Period04:

$$\mathrm{HJD_{max}} = 2,452,520.8081(18) + 0.1612751(5)E. \quad (2)$$

From Period04 we found a frequency of 7.3394 cycles day^{-1} for the entire run of *V* data and a frequency of 7.1622 cycles day^{-1} from the entire run of *B* data. From two separate nights on which two minima were present in the data, we estimated a period of about 0.140 days. Converting the two frequencies to periods and averaging the three period estimates, we found a new starting point of 0.1386 days, or 7.2137 cycles day^{-1}. It must be pointed out that the *Hipparcos* period and this potential new period differ by an almost exact 1 day alias, as shown by $f_{Hip} = 6.201$ cycles day^{-1}

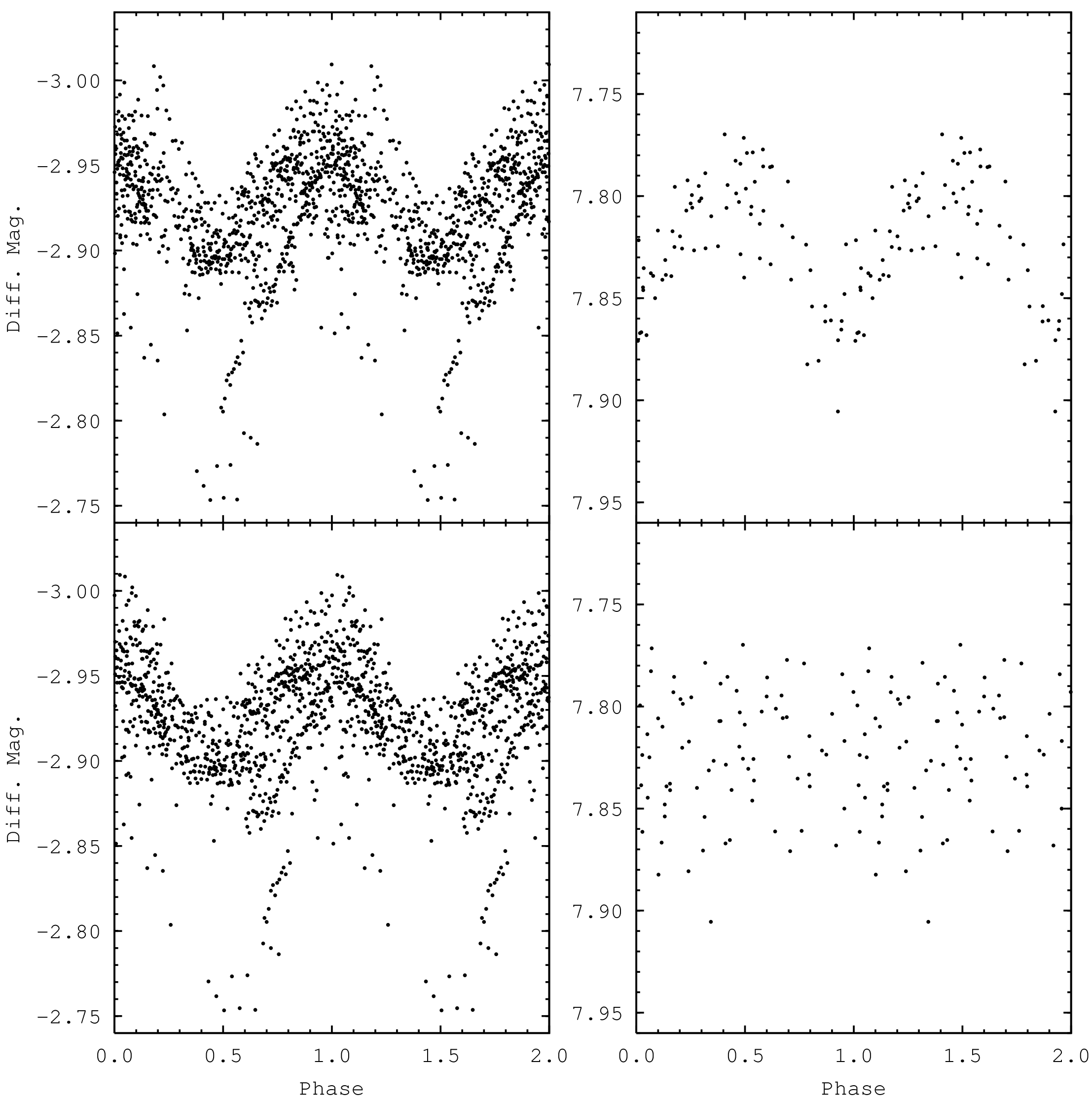

FIG. 7.—Phased light curves for V1438 Aql. *Top left:* Current *V* data phased using eq. (2). *Bottom left: V* data phased with eq. (3). *Top right: Hipparcos* data phased with eq. (2). *Bottom right: Hipparcos* data phased with eq. (3).

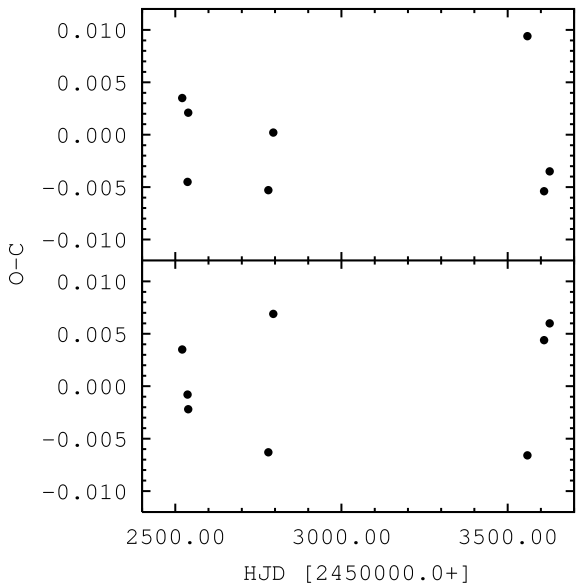

Fig. 8.—$(O - C)$ diagrams for V1438 Aql. The top panel was generated using eq. (2), and the bottom panel was generated using eq. (3). These are averaged $(O - C)$ values over all filters.

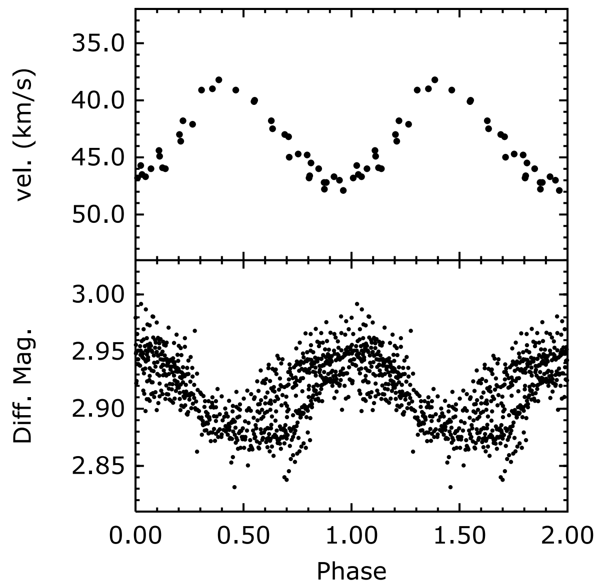

Fig. 10.—Phased radial velocity curve and *V* light curve for V1438 Aql. Both were phased using eq. (3).

and $f_{\rm new} = 7.214$ cycles day^{-1}. This is a little bit of a concern. The best fit to the times of maximum light for this potential new period is given in equation (3) and yields only slightly improved errors:

$$\text{HJD}_{\max} = 2,452,520.8082(16) + 0.1388043(4)E. \quad (3)$$

The strongest evidence for the new period lies in the distance between consecutive minima on two different nights. However, the evidence for the revised *Hipparcos* period being correct is a little more compelling. In Figure 7 we show our phased *V* data along with the phase data from *Hipparcos*. Clearly, the new period does not phase the *Hipparcos* data. For the current data the quality of the two phased light curves is almost identical. In both curves there is a clear offset of some of the data by as much as 0.1 mag. The differential photometry used the same comparison stars in all cases, and there is no evidence of variation in the comparison stars. Therefore, this magnitude drop is intrinsic to V1438 Aql and could be caused by a binary companion. However, this conclusion needs to be examined with a larger data set.

In Figure 8 we show the $(O - C)$ diagrams generated for each period. We have taken the average over all filters for each maxima to generate this plot. An examination of the bottom panel, and the values in Table 5, shows an up-and-down pattern in the $(O - C)$ values that might be indicative of an orbiting binary system. Unfortunately, the time density of the data is insufficient to see a convincing pattern and again calls for further observing.

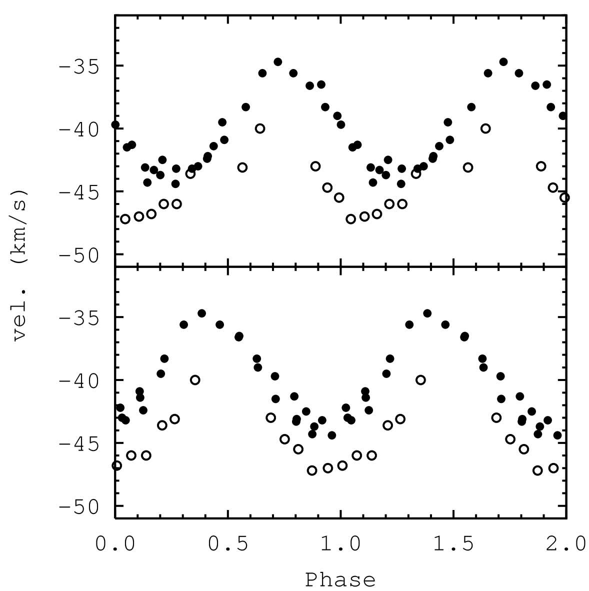

Fig. 9.—Phased radial velocity curves for V1438 Aql. The top panel was phased using eq. (2), and the bottom panel was phased using eq. (3). Data from 2002 are represented by open circles, and 2004 data are represented by filled circles. The two highest value points from 2002 are the June data.

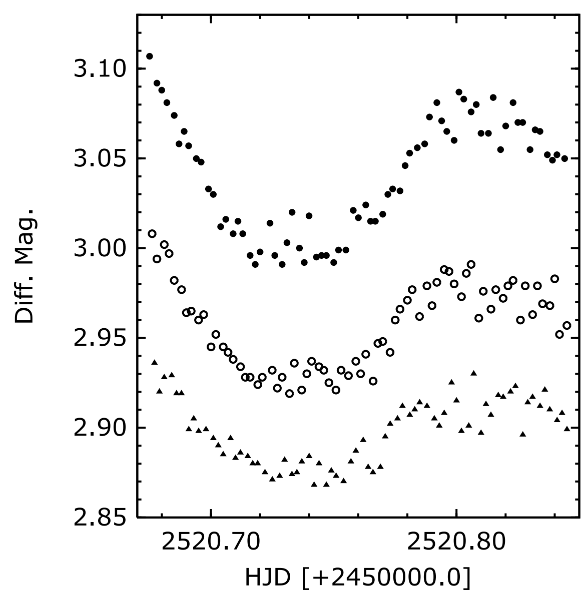

Fig. 11.—Single-night light curves in the *B* (*filled circles*), *V* (*open circles*), and *R* (*triangles*) filters for V1438 Aql.

Finally, we turn our attention to the radial velocity measurements for V1438 Aql. The observations were taken in 2002 June, 2002 August, and on three nights in 2004 August. Once again, we used equations (2) and (3) to phase the radial velocities. The result is shown in Figure 9. In both cases there is a definite shift between the 2002 and 2004 data. The average velocity for the 2002 data is about -39.2 km s^{-1} and for the 2004 data is -42.7 km s^{-1}. But, the full amplitude is about 9.7 km s^{-1} for both epochs. As stated earlier, this could be from a binary orbit, but there are insufficient data.

In Figure 10 we show the phased radial velocity data with the phased *V* photometry, both using equation (3). All radial velocity data have been shifted to match the 2002 August values. The one fainter night of photometry has been removed from the phased light curve for clarity. We note that, on average, V1438 Aql's light curve has a slow rise and a fast decay. In Figure 11 we show the *B*, *V*, and *R* curves for one night of data. The inverted shapes of the light curve and radial velocity curve, along with the lower amplitudes as we move to redder filters, clearly show this system to have a pulsational component.

4. CONCLUSION

For a lower amplitude δ Scuti we find that V966 Her is amazingly stable. We refine the period of pulsation to be 0.1330302 days and find no indication of long-term variation in the $(O - C)$ diagram. The stability of the period makes V966 Her easy to monitor. Perhaps the greatest need for V966 Her is a large enough data set to examine the frequency content in detail to explain the shape variations seen in the light curves. In this way V966 Her is an excellent candidate for an asteroseismology study, since there are no conflicting effects.

We find that V1438 Aql is another δ Scuti with interesting characteristics. We find a revised *Hipparcos* period of 0.1612751 days but also give a potential alternate period of 0.1388043 days. However, these periods are separated by a 1 day alias. We believe this star needs to be studied more extensively to clearly determine its true pulsational characteristics. Once again, a large uniform data set is required to resolve the ambiguity in the period.

The minor shift in the radial velocity values, the shifts in the $(O - C)$ diagram, and the one night of fainter photometry are indications of something changing in V1438 Aql. These changes might be caused by a binary companion, but the current data are not compelling enough to make the designation. A concentrated data set of photometry and radial velocities would help to clarify the nature of the changes seen in V1438 Aql.

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