The Photometric Period of V1674 Herculis (Nova Her 2021)

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Abstract A photometric study of the fast galactic nova V1674 Herculis (Nova Her 2021, TCP J18573095+1653396) was undertaken at the Burleith Observatory in Washington, DC, and supplemented with photometry from the Crimean Laboratory of the Sternberg Astronomical Institute and the Astronomical Institute of the Slovak Academy of Science. A total of 979 CCD observations were obtained over a time span of 53.8 days, yielding an orbital period: 0.152934 d ± 0.000034 d, epoch (HJD) of minimum light 2459408.74789.

1. Introduction

V1674 Herculis, (Nova Her 2021, TCP J18573095+1653396), R.A. = 18^h 57^m 30.98^s, Dec. = +16° 53' 39.6" (2000), was discovered by Seiji Ueda, Kushiro, Hokkaido, Japan, on 2021 June 12.537 UT (Ueda 2021). Spectral observations by Munari, Valisa, and Dallaporta identified the source as a classical nova on June 12.84 (Munari *et al.* 2021). Within three days the nova reached magnitude 5.23 I (6.76 V) (Romanov 2021), then faded by two magnitudes in 1.18 days—making this the fastest nova on record! (Quimby *et al.* 2021). Mroz *et al.* (2021) reported finding an 8.357-min. white dwarf spin period from r-band and g-band images in the Zwicky Transient Facility archives for the period 2018 March 26 to 2021 June 14. The field of V1674 Her is shown in Figure 1.

Schmidt (2021) reported a preliminary photometric period of 0.07115 d ± 0.000044 to the Central Bureau for Astronomical Telegrams on 23 July 2021. However, on 9 Aug. 2021, Shugarov and Afonina (2021) obtained an orbital period of 0.15290(3) d. Shugarov showed that the 0.07-day period was a half-day alias of the true orbital period; that is, with P_1 = 0.1529 d, the alias P_2 is found by $1/P_2 = 1/P_1 + 1$ and $P_2/2 \approx 0.07$ d. Shugarov's orbital period was confirmed three days later by (Patterson *et al.* 2021). By late July 2021 the nova faded beyond the limits of Burleith Observatory.

2. Observations

At Burleith Observatory, Washington, DC, CCD observations were obtained with a 0.32-m PlaneWave CDK astrograph and SBIG STL-1001E CCD camera with an Astrodon Cousins I_c filter. Pixel size was 1.95 arc-seconds, yielding on average 2-pixel FWHM. Exposure times ranged from 30 to 300 seconds. The observatory computer was synchronized to USNO NTP before each observing session. Nova Her 2021 was a particularly challenging object, fading on average 0.1 mag./day. It would have been desirable to obtain a longer baseline of observations in Washington, but as the nova began its rapid fading, the dense smoke from Western state forest fires greatly hampered photometry by adding significant noise to the sky background.

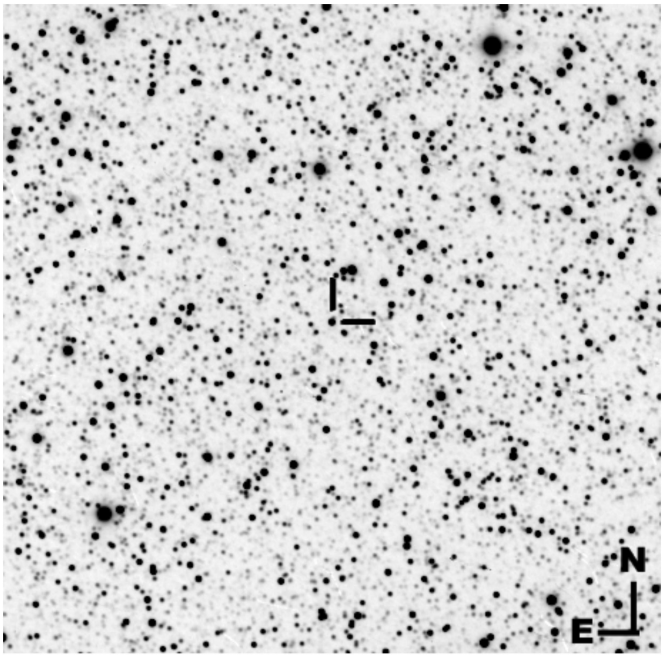

Figure 1. 15 arc-min field of V1674 Her, 13 July 2021.

Shugarov and Afonina (2021) observed with a 0.60-m f/12.5 telescope with FLI ML3041 at the Astronomical Institute of the Slovak Academy of Sciences at Stara Lesna, Slovakia, and with a 0.60-m f/12.5 telescope and FLI-39000 CCD at the Crimean Laboratory of the Sternberg Astronomical Institute, M.V. Lomonosov Moscow State University, Moscow, Russia. Their earliest observations were made with a 0.06-m Zeiss Sonnar T* 2.8/180-mm lens and SBIG ST-10XME CCD with

Cousins B, R, I filters. Their Cousins I band observations were used in this study.

During the span of observations the maximum amplitude of I_c magnitudes increased in a nearly linear manner, as seen in Figures 2 and 3.

3. Reductions

At Burleith Observatory, synthetic aperture photometry was performed using C-Munipack 2.1.29 (Motl 2021), with an aperture of radius 3.6 pixels. Heliocentric corrections were applied to dates of observation. Comparison stars (Table 1) were selected to avoid CCD saturation. Cousins I-band differential ensemble photometry was performed using the comparison stars in Table 1, from AAVSO chart sequence X26663ABW.

At CL Sternberg and at Stara Lesna multicolor CCD photometry was performed using apertures of ~8–10 arcsec. The single standard comparison star 000-BMD-913 was used for the 0.6-m observations. For the wider field of the 0.06-m Zeiss Sonnar observations the standard comparison star was 000-BCD-834.

Table 2 and Figure 4 provide nightly mean times of observation (HJD – 2400000), observed mean magnitude I_c, mean error of the magnitudes, and instrument used. (The slight zero-point offset between observatories is of no consequence, as nightly mean magnitudes were removed.) An example night's observation is shown in Figure 5.

4. Analysis

Prior to Fourier analysis, each nightly observation set from all observers was pre-processed by subtracting nightly average brightness and removing nightly linear trends. Period analysis was performed using Peranso 2.60 software (Paunzen and Vanmunster 2016), computing an ANOVA spectrum of 100,000 steps over the frequency range 0.3–16 c/d. Figures 6 and 7 show the spectral window with its 1-day alias and the ANOVA frequency of V1674 Her, 6.53875 cycles/day with various aliases. Pre-whitening removing this frequency plus aliases 6.54, 6.03, and 5.55 c/d revealed no other significant periods.

A folded double-phase plot of the most prominent period is shown in Figure 8. The solid curve shown is a 50-point averaging with spline interpolation.

The period error estimate (in parentheses) in the following summary Table 3 are computed by Peranso to provide a 1-sigma confidence level on the period P equal to the line width at the Mean Noise Power Level at P, using the method in section 4.4 of (Schwarzenberg-Czerny 1991); the epoch of extremum is found from a 7-degree polynomial fit to the observations.

5. Conclusion

The fast nova V1674 Her (Nova Her 2021) has been a particularly difficult object for urban photometry, because of its relatively fast fading during a period of coast-to-coast smoke obscuration in the United States. A preliminary Lomb-Scargle solution at Burleith Observatory was based on insufficient observations in the later stages when the double-humped magnetic polar light curve could be observed. Early on, the orbital period was apparently obscured by its bright disk material. The observations from Slovakia and Russia were invaluable in finding the true orbital period. The light curve of V1674 Her shows double humps at phase 0.5, a characteristic of magnetic cataclysmic variables, such as the polars AM Her and TZ Vir.

Table 1. Photometry comparison stars.

AUID	*R.A. (2000)* *h m s*	*Dec. (2000)* *deg ′ ″*	*Ic*	*Mag. Error*
000-BMD-913	18 57 41.50	+16 57 29.3	11.250	(0.175)
000-BMD-915	18 57 38.32	+16 57 29.8	11.908	(0.158)
000-BCD-758	18 58 11.66	+16 45 10.0	11.944	(0.041)
000-BMD-912	18 57 42.72	+17 01 13.9	10.838	(0.173) (check star)
000-BCD-834	18 58 56.83	+16 51 07.3	8.932	(0.087)

Table 2. Nightly mean magnitudes I_c.

HJD	*Mag. I_c*	*Error*	*Instrument*
59379.38359	6.188	0.018	6-cm Stara Lesna
59380.43751	7.031	0.063	6-cm Stara Lesna
59382.45018	8.144	0.045	6-cm Stara Lesna
59383.72617	8.859	0.003	32-cm Burleith
59384.46286	8.908	0.063	6-cm Stara Lesna
59385.49030	9.213	0.060	6-cm Stara Lesna
59386.48081	9.497	0.068	6-cm Stara Lesna
59388.46603	10.033	0.042	6-cm Stara Lesna
59394.43554	11.345	0.013	6-cm Stara Lesna
59395.65032	11.549	0.004	32-cm Burleith
59398.65690	12.007	0.010	32-cm Burleith
59401.67120	12.413	0.012	32-cm Burleith
59402.62504	12.543	0.014	32-cm Burleith
59405.58067	12.865	0.019	32-cm Burleith
59407.39159	13.109	0.048	60-cm Stara Lesna
59407.58429	13.051	0.030	32-cm Burleith
59408.73693	13.161	0.013	32-cm Burleith
59409.45503	13.371	0.023	60-cm Stara Lesna
59415.67780	13.671	0.034	32-cm Burleith
59416.67040	13.715	0.041	32-cm Burleith
59417.42635	13.893	0.049	60-cm Stara Lesna
59419.54054	13.999	0.034	60-cm Stara Lesna
59424.32052	14.186	0.055	60-cm CL Sternberg
59425.31605	14.234	0.033	60-cm CL Sternberg
59426.33177	14.248	0.045	60-cm CL Sternberg
59427.37227	14.268	0.063	60-cm CL Sternberg
59428.32811	14.267	0.046	60-cm CL Sternberg
59429.35967	14.302	0.037	60-cm CL Sternberg
59430.40949	14.354	0.054	60-cm CL Sternberg
59431.36096	14.367	0.044	60-cm CL Sternberg
59432.35535	14.428	0.054	60-cm CL Sternberg
59433.36201	14.482	0.056	60-cm CL Sternberg
59437.44959	14.753	0.070	60-cm CL Sternberg

Table 3. Period estimate parameters for V1674 Her.

Parameter	*Value*
Period (d)	0.152934 (0.000034)
Period (h)	3.6704 (0.0008)
Amplitude (mean curve) (mag. I_c)	0.0488
Number of observations	979
Time span (d)	53.80
Epoch of minimum	2459408.74789 (0.0031)

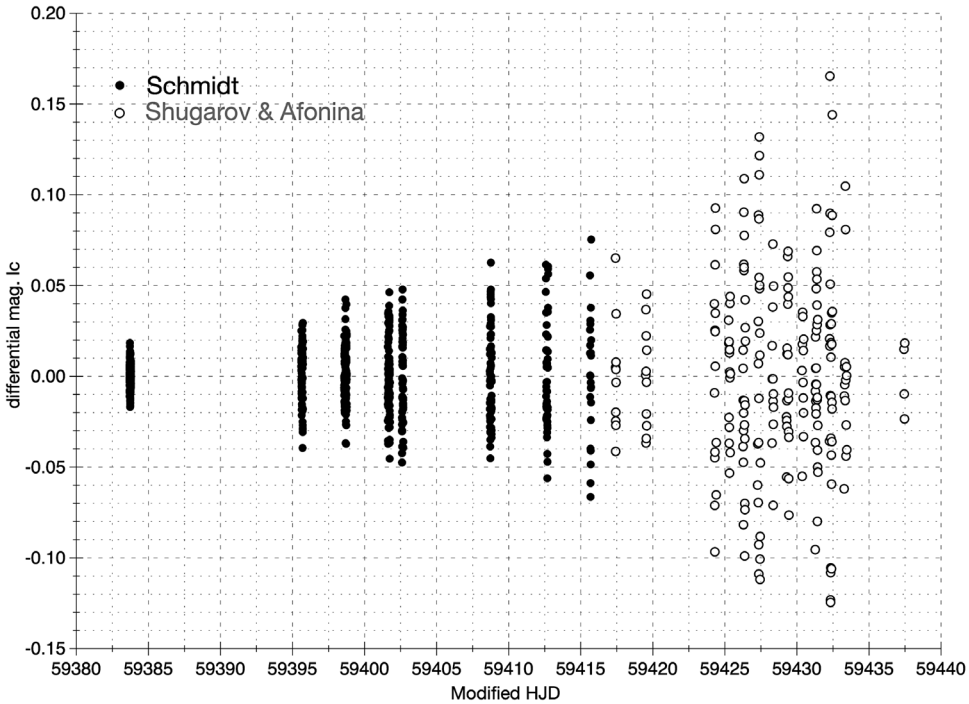

Figure 2. Observations of V1674 Her.

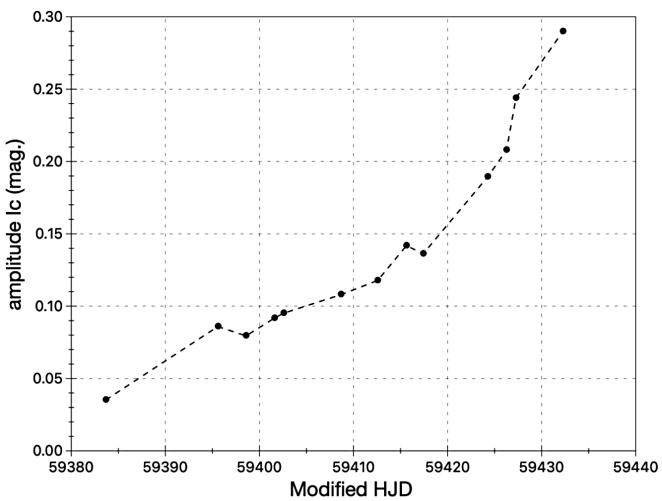

Figure 3. Observed maximum amplitude of I_c observations.

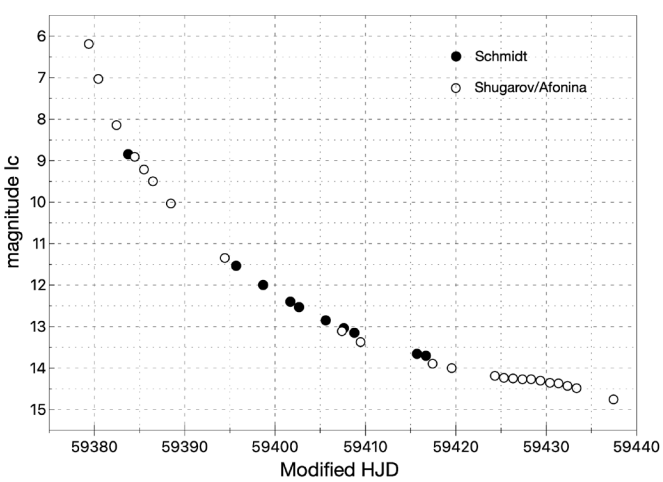

Figure 4. Nightly mean I_c magnitudes.

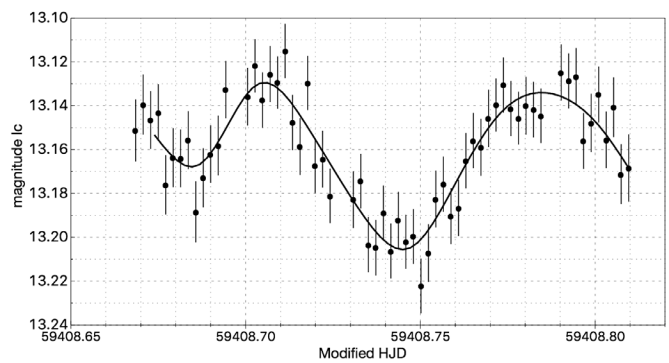

Figure 5 Example observation, Burleith Observatory, 13 July 2021.

The humps result from domination by the radiation of cyclotron emission of electron cooling in shock-treated columns of gas following the white-dwarf's magnetic field lines to impact with its hot surface (Gänsicke *et al.* 2001).

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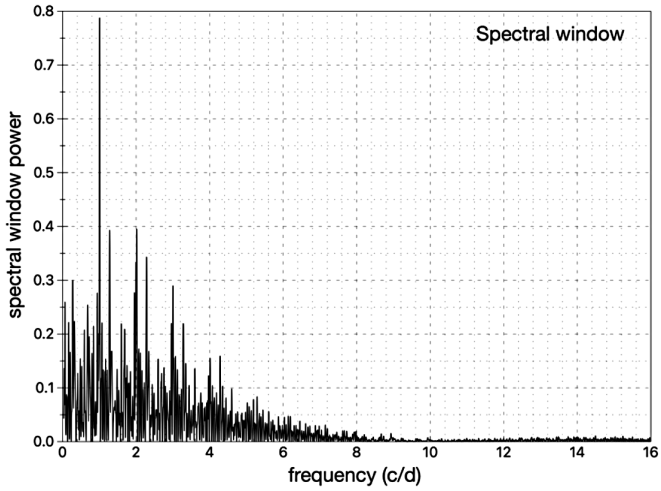

Figure 6. Observing window power spectrum.

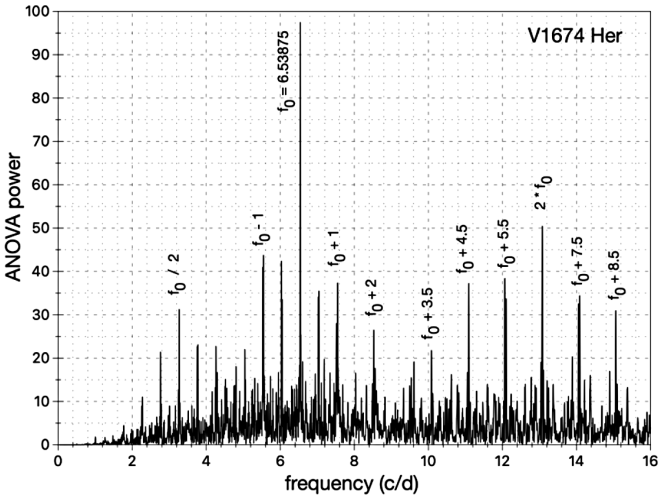

Figure 7. ANOVA periodogram of V1674 Her.

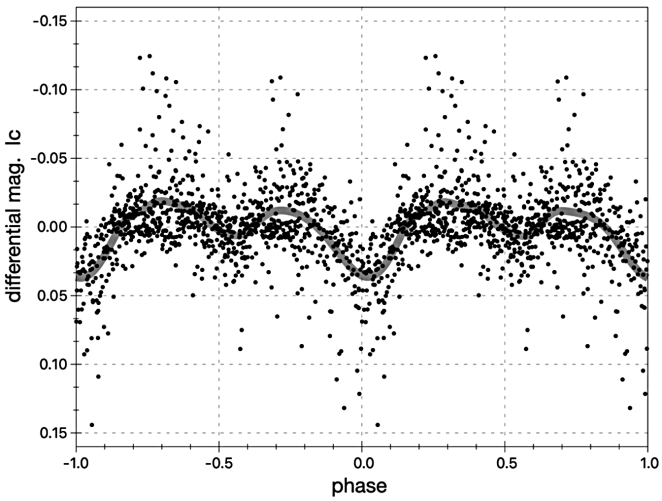

Figure 8. Double phased plot with spline interpolated smoothing (solid line).

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