The Photometric Period of V1112 Persei (Nova Per 2020)

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Abstract A photometric study of V1112 Persei (Nova Persei 2020) has been undertaken at the urban Burleith Observatory in Washington, DC, where 2,400 CCD observations were obtained over a time span of 42.02 days. A photometric period was obtained: 2.2257 ± 0.0011 h, epoch (HJD) of minimum light 2459192.612, with amplitude 0.010 magnitude (Cousins I). The serendipitous discovery of two new variable stars, BD +43 984 and GSC 02891-02799, is reported.

1. Introduction

V1112 Persei, (Nova Persei 2020, TCP J04291884+4354232), R.A. $04^h\ 29^m\ 18.85^s$, Dec. +43° 54' 23.0" (2000), was discovered on 2020 November 25.807 UT by Seiji Ueda (2020) at Kushiro, Hokkaido, Japan. An independent discovery on 2020 November 25.844 UT was made by Korotki, Sokolovsky, and Smolyankina (Ueda 2020). Munari *et al.* (2020) categorized it as a classical nova. Banerjee *et al.* (2020) reported its transition into a typical Fe II nova. Novae are typically reddened, making them ideal for near-infrared observing at high cadence from bright urban sky locations. This is the fourth recent nova since 2019 with a photometric period measured at Burleith Observatory (Schmidt 2020a, 2020b, 2020c). A preliminary photometric period reported to the *Central Bureau for Astronomical Telegrams* was published on January 9, 2021 (Schmidt 2021).

2. Observations

At Burleith Observatory, CCD observations were obtained with a 0.32-m PlaneWave CDK and SBIG STL-1001E CCD camera with an Astrodon Cousins I_c filter. Flat-fields and dark frames were applied in real time using The SkyX Professional Edition version 10.5.0 (Software Bisque 2020). Exposure times ranged from 8 to 120 seconds.

3. Reductions

Synthetic aperture photometry was performed using C-Munipack 2.1.29 (Motl 2020). Differential ensemble photometry used the comparison stars from AAVSO chart sequence X25769ASF (Table 1), seen in Figure 1.

Hourly mean magnitudes of all observing sessions, including those not used in period analysis, are shown in Table 2 and Figure 2. Example observing sessions are shown in Figures 3a–3d.

4. Analysis

Observed magnitudes were pre-processed by subtracting nightly means, then detrended by removing a linear fit to remove the nova's long-term decline. Compare the result of this process, Figure 4, with the original observations in Figure 3c.

Period analysis was then performed using Peranso 3.0 software (Paunzen and Vannmuster 2016), applying several period analysis techniques including the Date-Compensated Discrete Fourier Transform (DCDFT), two Analysis of Variance (ANOVA) methods, and the generalized Lomb-Scargle method. Confidence in the results is gained when a period is found using multiple methods. DCDFT is particularly useful for variable star observations in its ability to process unevenly spaced data. Nova Persei's 5.5 magnitude drop in 42 days required exposure times varying from 8 to 120 sec. As Templeton (2004) pointed out, two factors determining the resolution of a period determination by time series analysis are the time span of observations and the Fourier sampling frequency. In practice the maximum sampling rate is usually chosen as 2 to 5 multiples of the Nyquist frequency, $f_{Ny} = 1/(2\Delta t)$ for observing interval Δt. For an average $\Delta t = 60$ sec this results in $f_{Ny} = 1/720$ day, or 30,240 Fourier samples over our span of 42 days. As Thomson (1982) remarks, "…the sample size must be extraordinarily large for the periodogram to be reasonably unbiased." Figure 5 shows the DCDFT periodogram computed with 50,000 Fourier samples. The spectrum peaks at 10.783 ± 0.006 cycles / day (with associated 1 c / d aliases), period 2.2257 ± 0.0011 h.

A folded double-phase plot, is shown in Figure 6. A 512-point averaging with 128-point spline interpolation is shown (solid line).

The period was tested for significance using the Peranso False Alarm Probability (FAP) computations. A Fisher Monte Carlo Randomization Test, which keeps observation times fixed while randomizing the order of the magnitude observations over 200 permutations, searches for spectral responses due solely to observational biases (Moir 1998). FAP 1 computes the probability that *no* period of value P is present in the data, and FAP 2 the probability that *any other* significant periods are present in the data. The FAP are given in a range of 0 to 1, with values below 0.01 (1%) indicating very secure solutions (Paunzen and Vanmunster 2016). For P = 2.2257 h the Peranso values of both FAPs were 0.000 (probability of each < 0.05%).

The resulting period information is summarized in Table 3.

5. Discovery of two field variable stars: BD +43 984 and GSC 02891-02799

In the AAVSO chart sequence X25769ASF for V1112 Per, one of the AAVSO comparison stars, BD +43 984 in Figure 1, was found to be variable. Its AUID is 000-BNS-433, chart label 105. It is a 2.9-arc second double, WDS 04303+4408 in the *Washington Double Star Catalog* (USNO 2020;

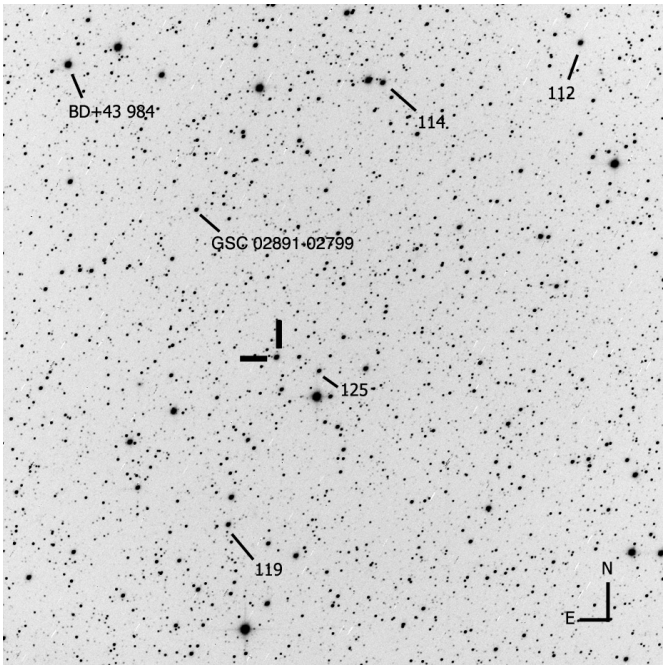

Figure 1. 30 arc-min field of V1112 Persei.

Table 1. Comparison stars (C = comparison, K = check).

AUID	R.A. (2000) h m s	Dec. (2000) ° ′ ″	C/K	Label	I_c	Mag. Error
000-BNS-435	04 27 56.78	+44 09 13.0	C	112	10.638	(0.160)
000-BNS-436	04 28 49.69	+44 07 27.6	C	114	10.687	(0.143)
000-BNS-437	04 29 32.14	+43 46 24.5	C	119	11.151	(0.140)
000-BNS-438	04 29 07.55	+43 53 42.6	K	125	11.650	(0.137)

unresolved in these CCD observations). An ANOVA time series analysis of 2,084 observations of this star yields a period of 0.3489 ± 0.0003 d, mean magnitude 9.51 in Cousins I_C, amplitude 0.023 magnitude I_c (Figure 7). ANOVA works particularly well for variables with small differences in the depths of minima, a defining characteristic of W Ursae Majoris variables (Lucy 1968), and is classified as a probable EW by (Otero 2021). It has now been added to the AAVSO VSX with a new AUID designation, 000-BNT-120.

A second field variable star, GSC 02891-02799 was also found to be a possible δ Scuti variable from an ANOVA analysis of 1,070 CCD images over a span of 29.2 d. This yielded a period of 0.1162 ± 0.0001 d (2.789 ± 0.002 h), epoch of maximum 2459224.382, with mean magnitude 11.89 in Cousins I_C, and amplitude 0.01 magnitude (Figure 8).

6. Conclusion

CCD observations of the classical nova, Nova Persei 2020, from a bright-sky urban observatory have detected a low-amplitude photometric period of 2.2257 h. The nova continued to remain photometrically active in early 2021, showing magnitude changes as much as 0.3 magnitude I_c in 6 hours (10 January 2021). Continued observations in standard bands should be of interest.

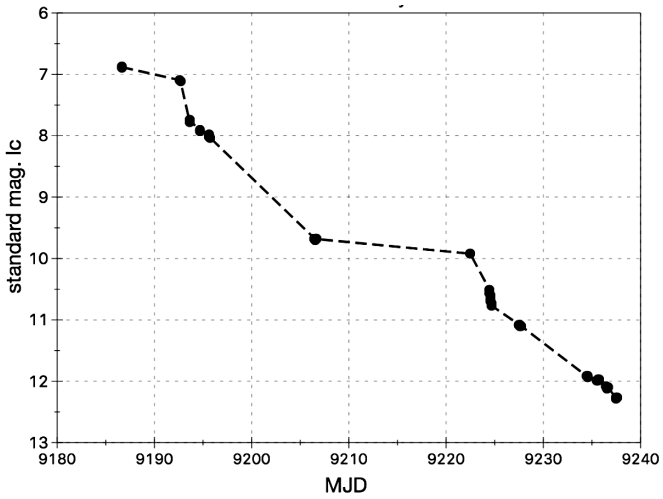

Figure 2. Hourly mean I_c magnitudes.

Table 2. Hourly mean magnitude (Ic) and magnitude error.

HJD 2450000+	Mag. I_c	Error	HJD 2450000+	Mag. I_c	Error
9186.658	6.880	0.009	9224.601	10.658	0.004
9186.679	6.884	0.009	9224.643	10.696	0.004
9192.641	7.095	0.008	9224.686	10.735	0.004
9192.677	7.107	0.009	9224.725	10.775	0.004
9193.640	7.781	0.004	9225.475	10.864	0.004
9193.675	7.741	0.004	9225.518	10.882	0.003
9194.650	7.925	0.004	9225.560	10.897	0.003
9194.686	7.914	0.004	9225.601	10.893	0.004
9195.582	7.972	0.003	9225.643	10.887	0.003
9195.624	7.984	0.003	9225.670	10.879	0.003
9195.665	8.011	0.003	9227.489	11.074	0.005
9195.700	8.028	0.003	9227.530	11.082	0.005
9206.492	9.677	0.004	9227.573	11.089	0.005
9206.534	9.698	0.003	9227.613	11.092	0.005
9206.576	9.703	0.003	9227.657	11.095	0.005
9206.613	9.688	0.003	9227.692	11.096	0.005
9206.662	9.679	0.003	9234.487	11.920	0.005
9206.687	9.683	0.003	9234.531	11.921	0.006
9222.473	9.922	0.004	9234.572	11.929	0.006
9224.475	10.510	0.005	9234.613	11.933	0.005
9224.517	10.560	0.004	9234.639	11.935	0.010
9224.560	10.601	0.004	9235.489	11.992	0.005

Table 3. Period test information summary.

Parameter	Value
Period (hours)	2.2257 ± 0.0011
Period (days)	0.09274 ± 0.00005
Mean amplitude (fit)	0.010
Number of observations	2,400
Time span (d)	42.02
Epoch (JD) of minimum	2459192.612

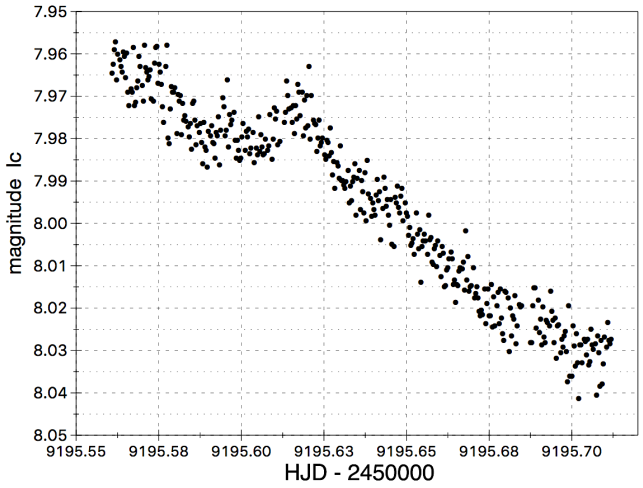

Figure 3a. Example session, December 12, 2020.

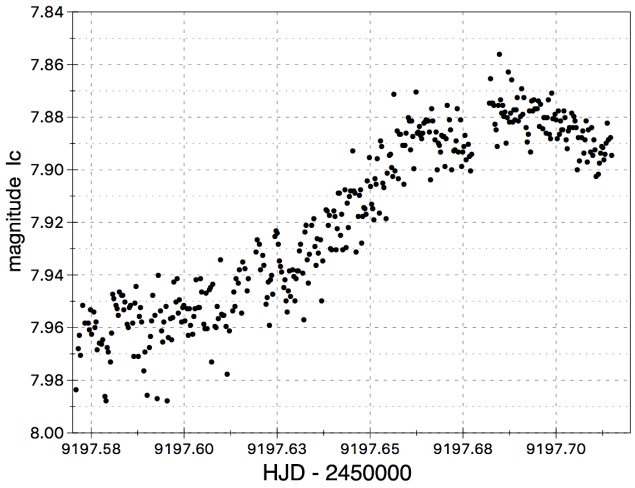

Figure 3b. Example session, December 14, 2020.

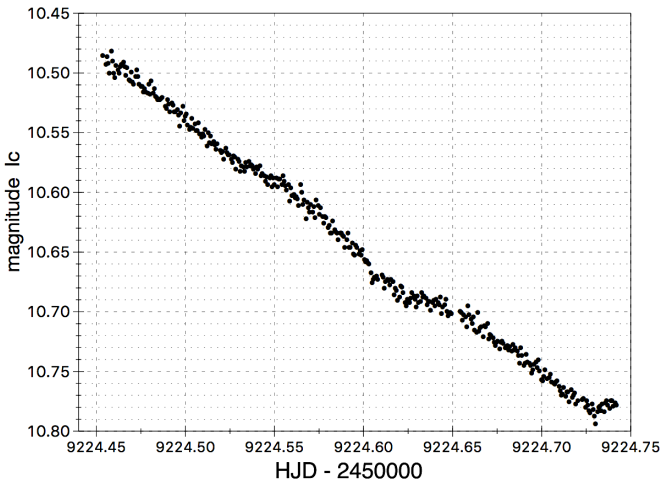

Figure 3c. Example session, January 10, 2021, with large magnitude drop.

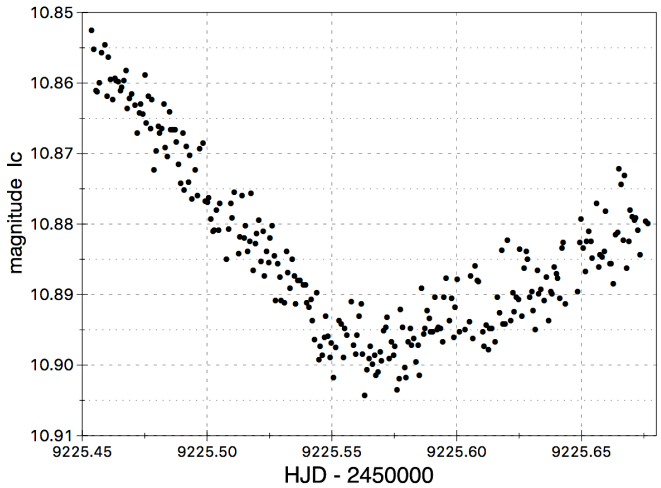

Figure 3d. Example session, January 11, 2021.

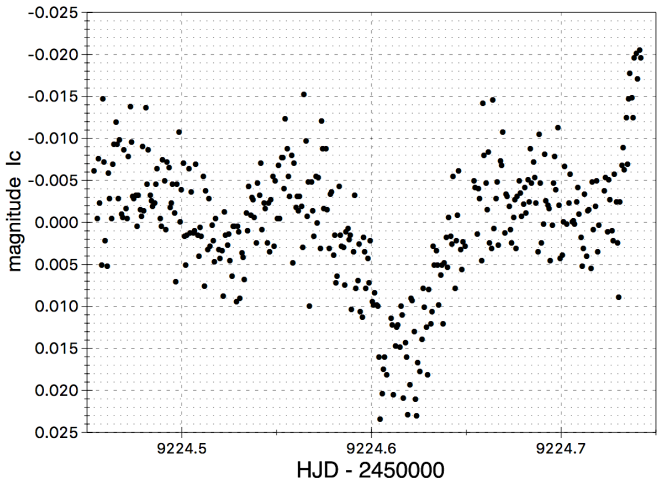

Figure 4. Observations of Figure 3c detrended.

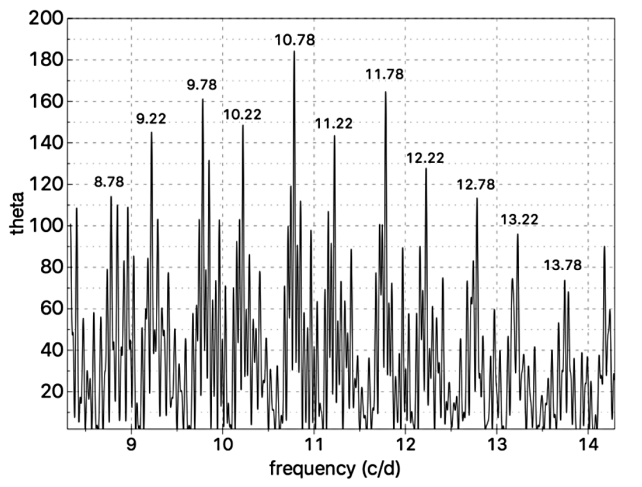

Figure 5. DCDFT spectrum.

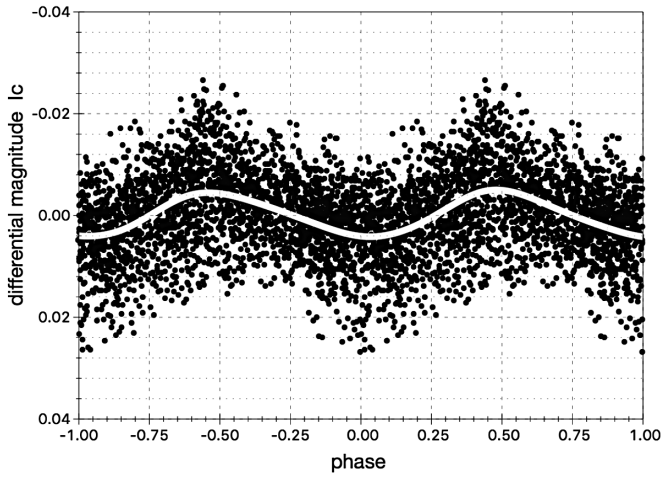

Figure 6. V1112 Persei, double phased plot with spline interpolated fit.

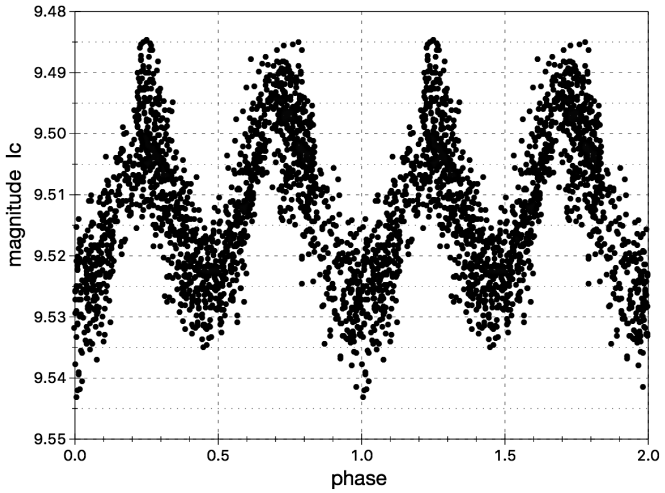

Figure 7. Variable field star BD+43 984.

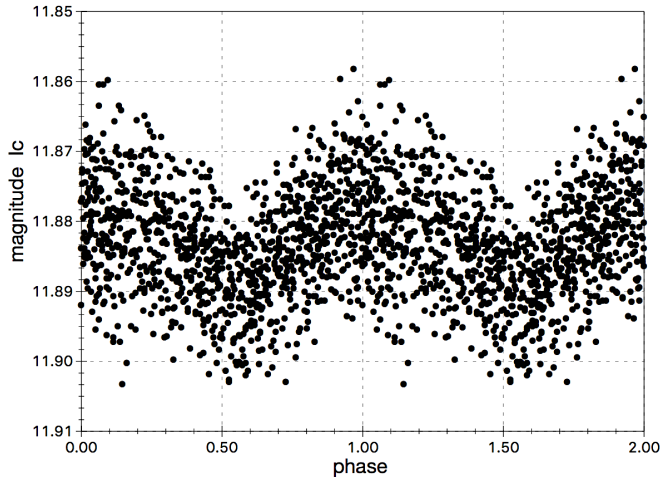

Figure 8. Variable field star GSC 02891-02799.

7. Acknowledgements

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References

Banerjee, D., Shahbandeh, M., Woodward, C., Evans, A., Hsiao, E., and Joshi, V. 2020, *Astron. Telegram*, No. 14256.

Lucy, L. 1968, *Astrophys. J.*, **153**, 877.

Moir, R. 1998, *Exp. Economics*, **1**, 87.

Motl, D. 2020, C-Munipack software utilities (http://c-munipack.sourceforge.net).

Munari, U., Castellani, F., Dallaporta, S., and Andreoli, V. 2020, *Astron. Telegram*, No. 14224.

Otero, S. 2021, private communication.

Paunzen, E., and Vanmunster, T. 2016, *Astron. Nachr.*, **337**, 239.

Schmidt, R. E. 2020a, *J. Amer. Assoc. Var. Star Obs.*, **48**, 13.

Schmidt, R. E. 2020b, *J. Amer. Assoc. Var. Star Obs.*, **48**, 53.

Schmidt, R. E. 2020c, *J. Amer. Assoc. Var. Star Obs.*, **49**, 95.

Schmidt, R. E. 2021, *Cent. Bur. Astron. Telegrams*, No. 4906, 1.

Software Bisque. 2020, The SkyX Professional Edition (https://www.bisque.com).

Templeton, M. 2004, *J. Amer. Assoc. Var. Star Obs.*, **32**, 41.

Thomson, D. J. 1982, *Proc. IEEE*, **70**, 1055.

Ueda, S. 2020, *Cent. Bur. Astron. Telegrams*, CBAT Transient Object Followup Reports, TCP J04291884+4354232, 2020 11 25.807.

United States Naval Observatory. 2020, *The Washington Double Star Catalog (http://www.astro.gsu.edu/wds).*