The Photometric Period of PGIR22akgylf (Nova Cygni 2022)

Richard E. Schmidt
1810 35th Street NW, Washington, DC 20007; schmidt.rich@gmail.com

ReceivedOctober 13, 2022; revised November 29, 2022; accepted November 30, 2022

Abstract A photometric study of the galactic nova PGIR22akgylf (Nova Cygni 2022) was undertaken at the Burleith Observatory in Washington, DC. A total of 1,075 CCD observations were obtained over a time span of 32.1 days, yielding an observed period 4.140 h ± 0.003 h, of amplitude 0.008 magnitude I_C. The epoch (HJD) of minimum light was 2459838.54041 (2022 September 16.0404 UT). A suspected ZTF variable in the field of the nova, GSC 02678-01797, was found to be multi-periodic.

1. Introduction

This is the seventh in a series of reports on the discovery of photometric periods of recent classical novae (Schmidt 2021). These *JAAVSO* reports serve a dual purpose: adding to the relatively few known orbital periods of novae, and hopefully inspiring urban astronomers to participate in nova research. The reddened color of galactic novae and their typically long period of outbursts lend them well to CCD observation—even in heavily light-polluted cities—when observing in the near infrared, as with the Cousins I_C filter and a monochromatic camera with sensitivity in the 700–900 nm region.

The year 2022 has brought the fewest number of galactic novae discoveries in eight years, as seen in Figure 1 (Mukai 2022). Thus, the discovery of PGIR22akgylf (Nova Cygni 2022, AT 2022sfe, ZTF22abazrjk), R.A. = $20^h 00^m 29.25^s$, Dec. = +34° 44' 49.8" (J2000), by the Palomar Gattini-IR survey on 2022 August 16 (De *et al.* 2022) was welcome news. Its spectroscopic identification as a slow nova, highly reddened by extinction at galactic latitude 2.5°, was made by its discoverers on 2022 August 29. The nova's position, about 53 arc-minutes southeast of η Cygni, was ideal for observing at low airmass from my Washington, DC, site in early evening.

As of 2022 October 12, nearly 60 days post-discovery, PGIR22akgylf had yet to begin its final decline in brightness. The 20 arc-minute field of PGIR22akgylf (I_C image) is shown in Figure 2.

2. Observations

At Burleith Observatory a total of 1,075 CCD observations of PGIR22akgylf were obtained between 2022 September 10.1 and October 12.0 UT with a 0.32-m PlaneWave CDK astrograph and SBIG STL-1001E CCD camera with an Astrodon I_C filter. Pixel size was 1.95 arc-seconds, yielding on average 2-pixel FWHM, and the field of view was 33 arc-minutes square. The observatory computer was synchronized to USNO NTP before each observing session. Images were de-darked and flat-fielded in real time. Exposure times ranged from 30 to 90 seconds.

3. Reductions

Cousins I-band differential ensemble photometry was performed using the comparison stars in Table 1, which are labeled in Figure 2. Synthetic aperture photometry was performed using C-Munipack 2.1.29 (Motl 2021). Heliocentric corrections were applied to dates of observation. Data from poor nights and large outliers were filtered out, leaving 1,075 images for analysis.

Table 2 and Figure 3 provide nightly mean times of observation in HJD and UT, observed nightly mean magnitudes I_C, standard error of the mean magnitudes, duration of nightly observing sessions, and mean air mass. Figure 4 shows a histogram of the distribution of air masses. A sample night's observation from 2022 September 28 is shown in Figure 5.

Table 1. Photometry comparison stars from AAVSO chart sequence X28196I.

No.	*AUID*	*R.A. (J2000) h m s*	*Dec. (J2000) ° ' "*	*Mag. I_C*	*Mag. Err.*	*(B–V)*
114	000-BPL-180	20 00 42.09	+34 46 44.0	10.548	0.085	0.719
116	000-BPL-181	20 01 01.38	+34 44 23.8	10.895	0.021	0.609
120	000-BPL-182	20 00 36.19	+34 53 37.0	11.196	0.024	0.604
124	000-BPL-183	20 00 30.69	+34 56 02.7	11.503	0.032	0.759
128	000-BPL-184	20 00 35.55	+34 56 57.9	12.056	0.037	0.638
132*	000-BPL-132	20 00 23.89	+34 56 48.3	12.376	0.049	0.646

* *Check star.*

Table 2. Nightly mean magnitudes I_C.

HJD	*UT*	*Mag. I_C*	*Stderr of Mean*	*Duration (hours)*	*Mean Airmass*
2459832.590511	Sep. 10.090	12.593	0.001	3.18	1.023
2459837.589513	Sep. 15.089	12.269	0.001	4.20	1.047
2459838.579091	Sep. 16.079	12.228	0.001	3.73	1.033
2459839.565689	Sep. 17.066	12.182	0.001	3.06	1.021
2459841.524425	Sep. 19.024	12.153	0.001	1.05	1.018
2459842.573287	Sep. 20.073	12.109	0.001	3.17	1.027
2459843.594962	Sep. 21.095	12.084	0.001	2.39	1.043
2459844.568964	Sep. 22.069	12.080	0.001	2.30	1.019
2459845.565741	Sep. 23.066	12.042	0.001	1.69	1.013
2459846.572885	Sep. 24.073	12.005	0.001	2.14	1.024
2459847.545851	Sep. 25.046	11.790	0.001	1.80	1.009
2459850.576200	Sep. 28.076	11.729	0.001	1.70	1.035
2459862.567876	Oct. 10.068	11.567	0.001	3.20	1.095
2459863.563666	Oct. 11.064	11.593	0.001	1.87	1.074
2459864.549373	Oct. 12.049	11.591	0.001	2.90	1.065

Table 3. Observation summary PGIR22akgylf (Nova Cygni 2022).

Period (d)	0.1725 (0.0001)
Period (h)	4.140 (0.003)
Amplitude (mean curve) (mag. I_C)	0.008
Number of observations used	1075
Time span (d)	32.1
Epoch of minimum	2459838.54041 (Sep. 16.0404, 2022)

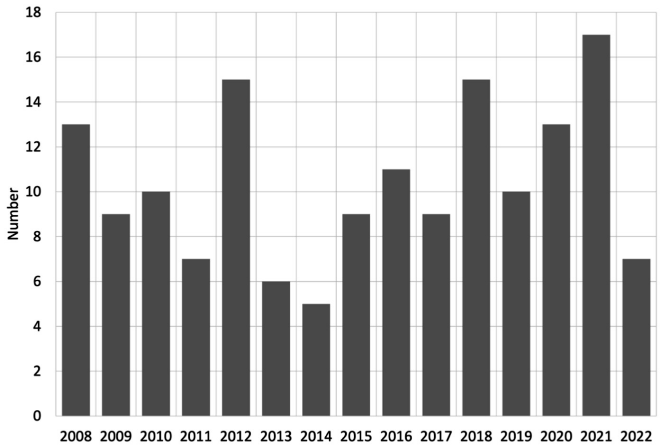

Figure 1. Annual numbers of galactic nova discoveries (Mukai 2022).

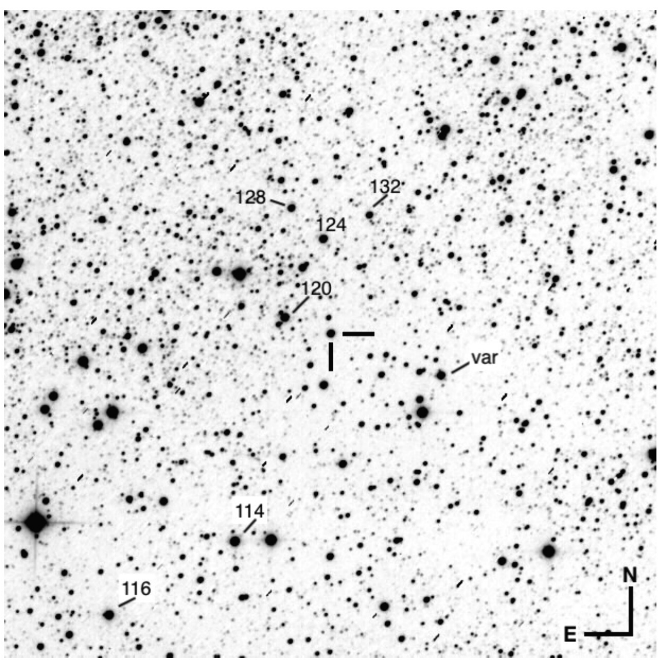

Figure 2. 20 arc-min field of PGIR22akgylf (center) and variable (“var”) in I_C.

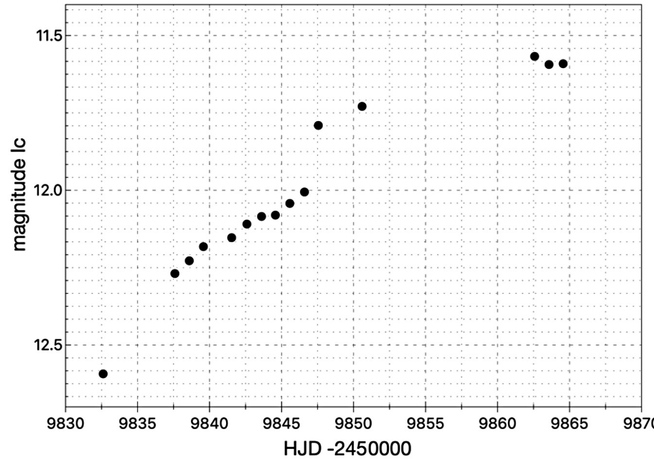

Figure 3. PGIR22akgylf nightly mean I_C magnitudes.

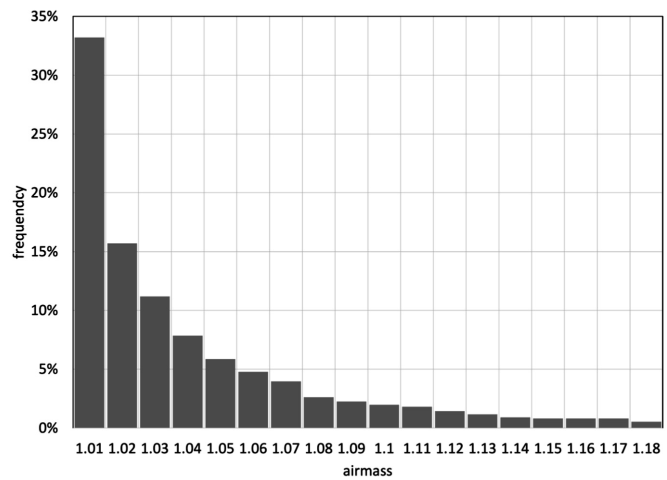

Figure 4. Histogram of airmass values.

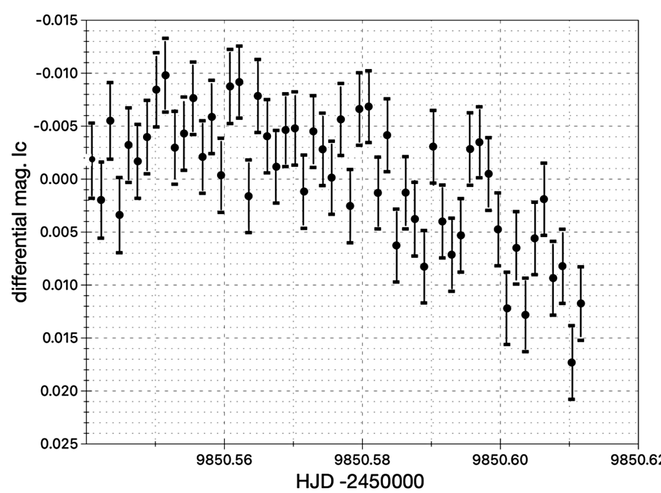

Figure 5. Example observations, 2022 September 28.

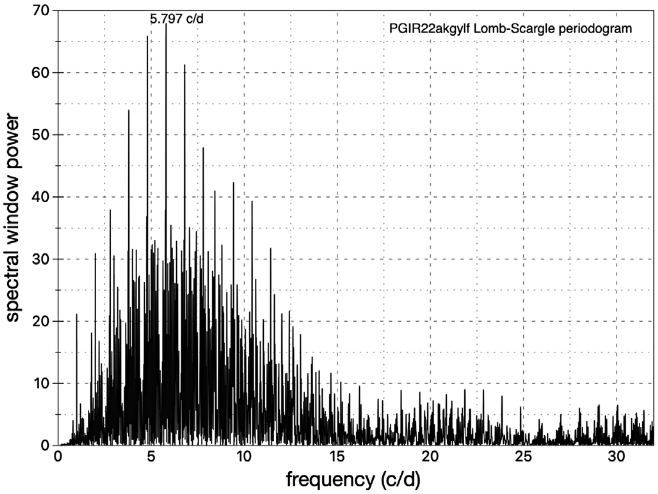

Figure 6. Wide Lomb-Scargle periodogram.

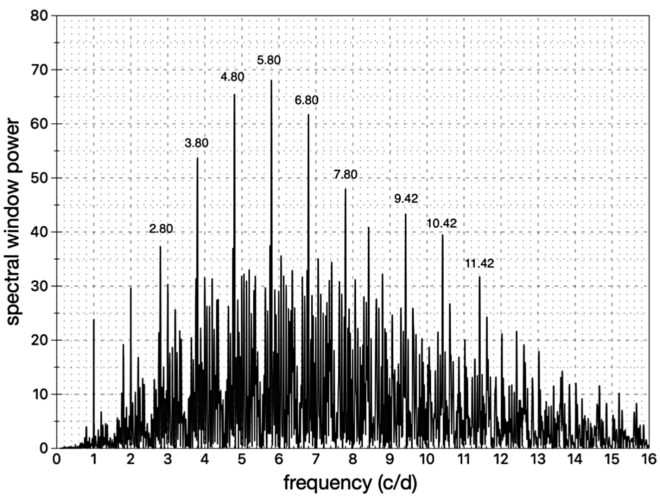

Figure 7. Detail, periodogram of PGIR22akgylf.

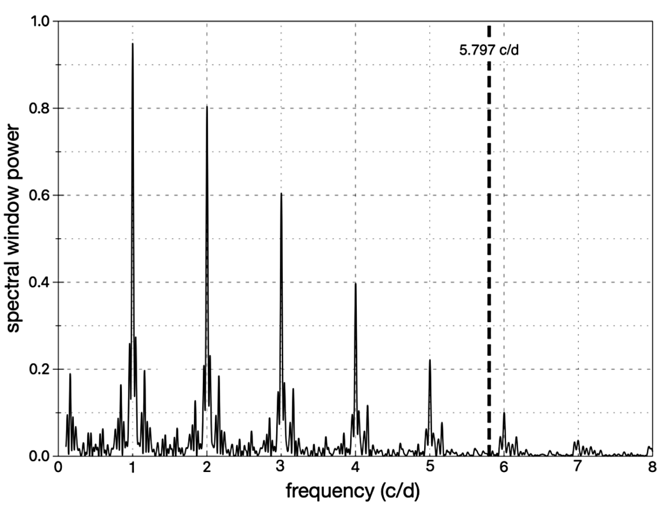

Figure 8. Spectral window of observations.

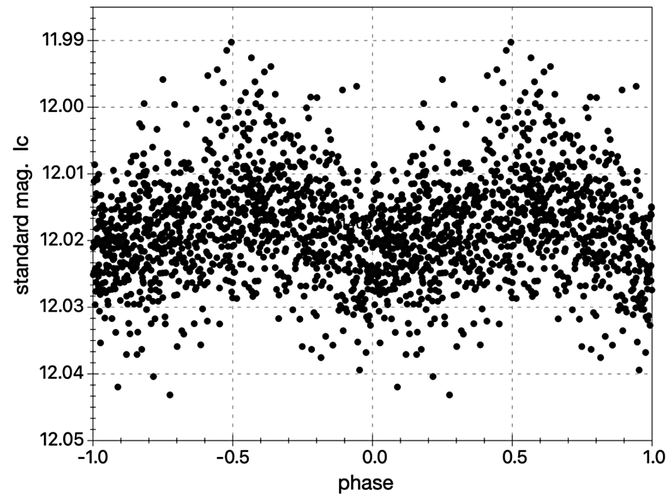

Figure 9. PGIR22akgylf, double-phase plot.

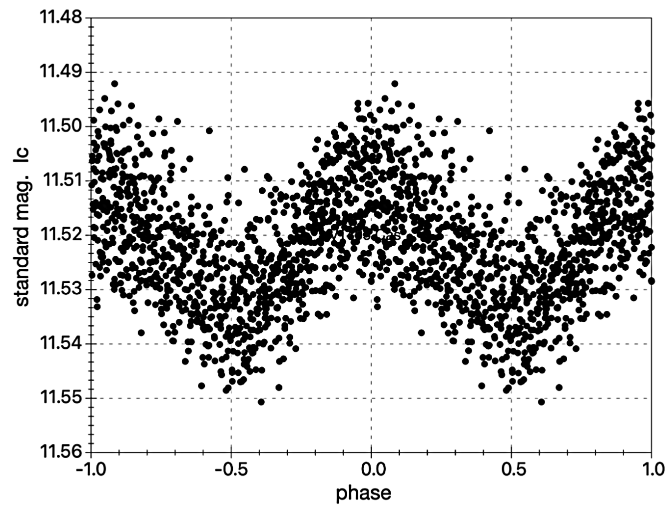

Figure 10. Phase plot of GSC 02678-01797, primary period = 1.4576 h.

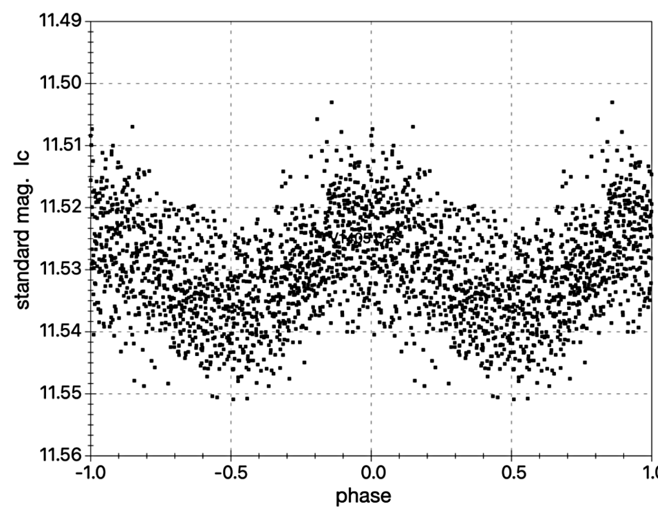

Figure 11. Phase plot of GSC 02678-01797, pre-whitened period = 1.859 h.

4. Analysis

Prior to Fourier analysis, each nightly observation set was pre-processed by subtracting the nightly average brightness. Period analysis was performed using Peranso 3.0.3 software (Paunzen and Vanmunster 2016), computing a Lomb-Scargle spectra of the observations. Because of the low signal-to-noise ratio of the nova light curve, solutions of 52,000 steps were computed.

Figure 6 shows a Lomb-Scargle periodogram over the frequency range 0–32 cycles / day, which peaks at 5.7973 cycles / day (4.139834 hours). This wide view shows the absence of strong signals at high frequencies. Figure 7 shows detail in the range 0–16 cycles/day. Note the labelled period aliases which appear at 0.5-day and 1-day intervals due to the diurnal nature of night observing. The observations were also analyzed using Peranso's phase binned Analysis of Variance (AoV) method (Schwarzenberg-Czerny 1989), which is ideal for period finding in non-sinusoidal signals. This method returned the same period, 4.140 h (± 0.003).

Figure 8 shows the spectral window for these observations, which displays artifacts caused by the cadence of observations. The absence of a peak at the observed frequency 5.80 cycles / day shows that this frequency is not an artifact of the observing window.

A folded double-phase plot of the most prominent period is shown in Figure 9.

Table 3 summarizes observed data for PGIR22akgylf with errors in parentheses. The period error estimate was computed by Peranso as the 1-sigma confidence level on the period P which equals the line width of its Mean Noise Power Level, using the method in section 4.4 of (Schwarzenberg-Czerny 1991). The two False Alarm Probabilities (FAPs) computed by Peranso were below 0.01 (1%), indicating strong confidence in the computed period. The epoch of extremum is found from a 7-degree polynomial fit to the observations using the Peranso software.

5. "Discovery" of a dual-period δ Scuti variable

Tens of thousands of stars appear in each 33 × 33 arc-minute field taken with this telescope and CCD. Photometry reduction programs such as C-Muniwin can generate plots of magnitude vs. standard deviation for each field object. Each object with heightened magnitude standard deviation is checked for possible periodicity. Examination of the field of PGIR22akgylf resulted in the "independent discovery" of a variable star, which was subsequently found by Sebastián Otero in Table 3, "unclassified suspected variables" of the "Zwicky Transient Facility Catalog of Periodic Variable Stars" (Chen *et al.* 2020). The variable ZTFJ200012.67+345156.7 (GSC 02678-01797) has ZTF period 1.45752 h and amplitude in g-band 0.045, from 145 ZTF observations. This variable has been assigned AAVSO AUID 000-BPL-178. Its position is R.A. = $20^h 00^m 12.68^s$, Dec. = +34° 43' 38.4" (J2000) (marked "var" in Figure 2). From 1,413 observations over 60.0 days I found the prominent period 1.4576 h ± 0.0007 h, with amplitude 0.019 magnitude I_C. The fast period and low amplitude is typical of δ Scuti variables. A double phase plot is shown below (Figure 10). As many δ Scuti variables are multi-periodic (with radial and non-radial pulsations), I performed pre-whitening of this period, revealing a second prominent period of 1.859 h ± 0.001 h, amplitude 0.011 magnitude (Figure 11).

6. Conclusion

The photometric variability of PGIR22akgylf, though of low amplitude, (0.008 magnitude I_C), is detected with a Lomb-Scargle spectral analysis based on a large number of observations. The four-hour period falls within the strong maximum at 3 to 4 hours which encompasses one-third of known novae orbital periods (Özdönmez *et al.* 2018; Fuente-Morales *et al.* 2021). In spite of its location in a heavily light-polluted city (Washington, DC), the modest telescope of Burleith Observatory produces Cousins I-band photometric measurements with a mean error of 0.005, and standard error 0.001 magnitude. The serendipitous "independent discovery" of a multi-periodic δ Scuti variable further adds to the enjoyment of CCD field photometry.

7. Acknowledgements

Schmidt wishes to thank Sebastián Otero, AAVSO, and James A. DeYoung, NRL/USNO (ret.) for helpful comments. Special thanks to the AAVSO for providing photometric standards from the AAVSO Comparison Star Database via its Variable Star Plotter utility.

References

Chen, X., Wang, S., Deng, L, de Grijis, R., Yang, M., and Tian, H. 2020, *Astrophys. J., Suppl. Ser.*, **249**, 18.

De, K., *et al.* 2022, *Astron. Telegram*, No. 15587, 1.

Fuente-Morales, I., Tappert, C., Zorotovic, M., Vogt, N., Puebla, E. C., Schreiber, M. R., Ederoclite, A., and Schmidtobreick, L. 2021, *Mon. Not. Roy. Astron. Soc.*, **501**, 6083.

Motl, D., 2021, C-Munipack software utilities (http://c-munipack.sourceforge.net).

Mukai, K. 2022, "Koji's List of Recent Galactic Novae," NASA, Goddard Space Flight Center, 22 Sep. 2022 (https://asd.gsfc.nasa.gov/Koji.Mukai/novae/novae.html).

Özdönmez, A., Ege, E., Güver, T., and Ak, T. 2018, *Mon. Not. Roy. Astron. Soc.*, **476**, 4162.

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

Schmidt, R. E. 2021, *J. Amer. Assoc. Var. Star Obs.*, **49**, 261.

Schwarzenberg-Czerny, A. 1989, *Mon. Not. Roy. Astron. Soc.*, **241**, 153.

Schwarzenberg-Czerny, A. 1991, *Mon. Not. Roy. Astron. Soc.*, **253**, 198.