

NEW LIGHTCURVES OF 33 POLYHYMNIA, 49 PALES, 289 NENETTA, 504 CORA, AND 821 FANNY

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Synodic rotation periods and amplitudes are found for 33 Polyhymnia 18.610 ± 0.001 hours, 0.12 ± 0.01 magnitudes; 49 Pales 20.709 ± 0.001 hours, 0.19 ± 0.01 magnitudes with 4 maxima and minima per cycle; 289 Nenetta 6.916 ± 0.001 hours, 0.20 ± 0.02 magnitudes; 504 Cora 7.587 ± 0.001 hours, 0.18 ± 0.01 magnitudes; 821 Fanny, 235 ± 1 hour, amplitude increasing from 0.22 to 0.28 magnitudes. For 821 Fanny the color index $V-R=0.37$, $H=11.763 \pm 0.018$, $G=0.079 \pm 0.018$.

Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter except where otherwise stated. Photometric measurement and lightcurve construction is with *MPO Canopus* software. To reduce the number of points on the lightcurves and make them easier to read, data points have been binned in sets of 3 with a maximum time difference of 5 minutes.

33 Polyhymnia. Five previous studies all found highly consistent rotational periods for 33 Polyhymnia: Zappala et al. (1982), 18.601 hours; Pilcher (2009), 18.609 hours; Pilcher (2011), 18.608 hours; Ferrero (2012), 18.604 hours; Behrend (2012), 18.604 hours. New observations on 9 nights 2018 Apr. 10 – May 17 provide a good fit to a bimodal lightcurve (Figure 1) with period 18.610 ± 0.001 hours, amplitude 0.12 ± 0.01 magnitudes, in complete agreement with earlier results.

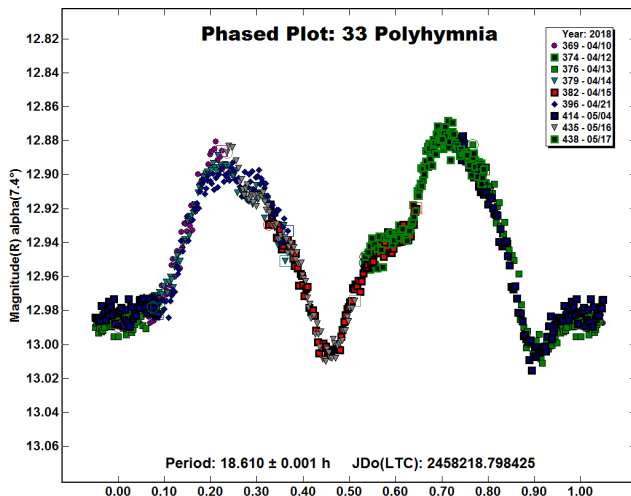


Figure 1. Phased lightcurve of 33 Polyhymnia.

49 Pales. Two early published rotation periods were by Schober (1979), 10.42 hours; and by Tedesco (1979), 10.3 hours, and for many years the period was believed to be near 10.4 hours. Behrend (2013) published a very sparse lightcurve which suggested a period <10 hours. Pilcher et al. (2016) made a much

more comprehensive investigation that found a period 20.704 hours with an unsymmetric quadrimodal lightcurve. Behrend (2016) complemented this study with a period 20.7057 hours. Pilcher (2017) at the next opposition found a period 20.705 hours. The new study published here confirms the recent results. Observations on 10 nights 2018 Apr. 4 – May 11 provide a good fit to a period 20.709 ± 0.001 hours, again with an irregular quadrimodal lightcurve, and amplitude 0.19 ± 0.01 magnitudes (Figure 2). This is consistent with other recent values.

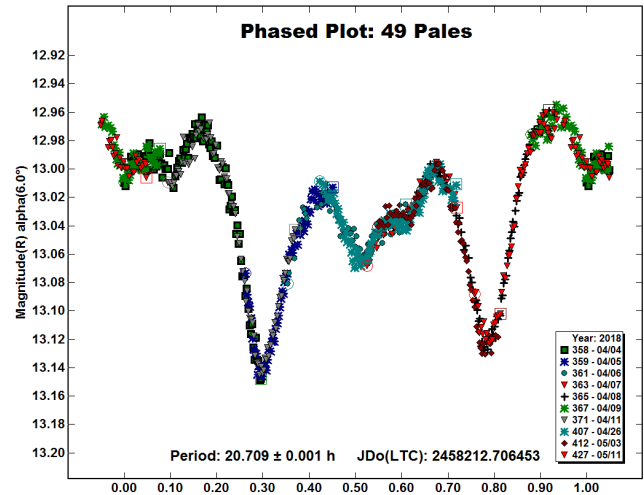


Figure 2. Phased lightcurve of 49 Pales.

289 Nenetta. Previously published period determinations are by Barucci et al. (1992), 6.902 hours; Behrend (2006), 6.9 hours; Behrend (2007), >8 hours; Behrend (2008), 6.94 hours; and by Lucas et al. (2011), 6.914 hours. New observations on 6 nights 2018 May 18 – June 18 provide a good fit to a lightcurve with period 6.916 ± 0.001 hours, amplitude 0.20 ± 0.02 magnitudes (Figure 3). This is consistent with most previous values.

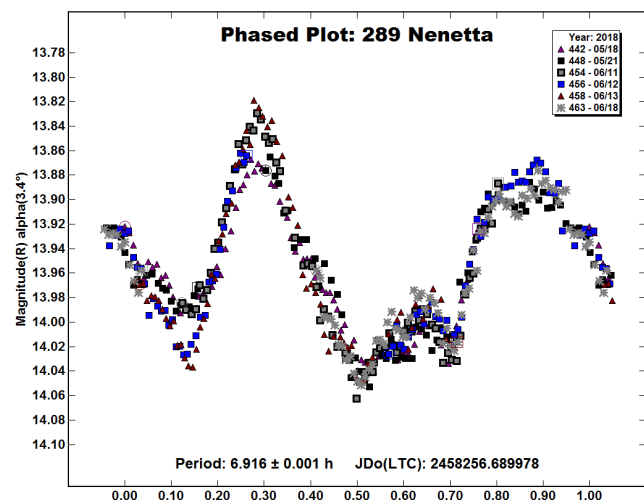


Figure 3. Phased lightcurve of 289 Nenetta.

504 Cora. Previously published period determinations are by Barucci et al. (1992), 24.06 hours; Behrend (2009), 7.591 hours; Higgins (2011), 7.588 hours; and by Waszczak et al. in the Palomar Transient Factory Survey, 7.592 hours in 2012 observations and 7.588 hours in 2013 observations. New observations on 6 nights 2018 April 16 – May 19 provide a good

fit to a lightcurve with period 7.587 ± 0.001 hours, amplitude 0.18 ± 0.01 magnitudes (Figure 4). A split halves plot of the double period 15.174 hours (Figure 5) shows that the two halves are almost identical and rules out the double period. This new result is in good agreement with most previous results.

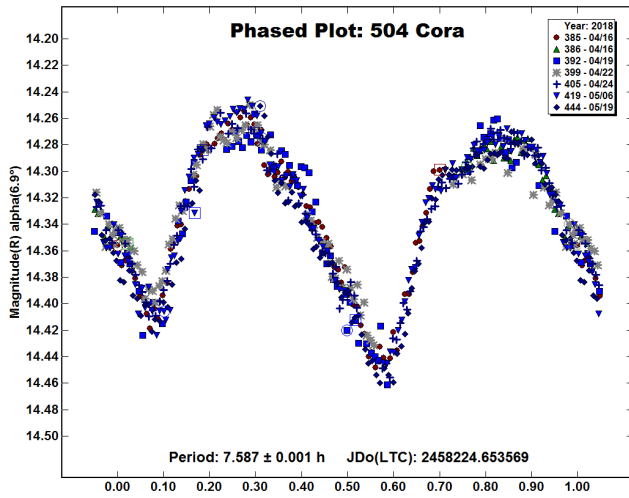


Figure 4. Phased lightcurve of 504 Cora.

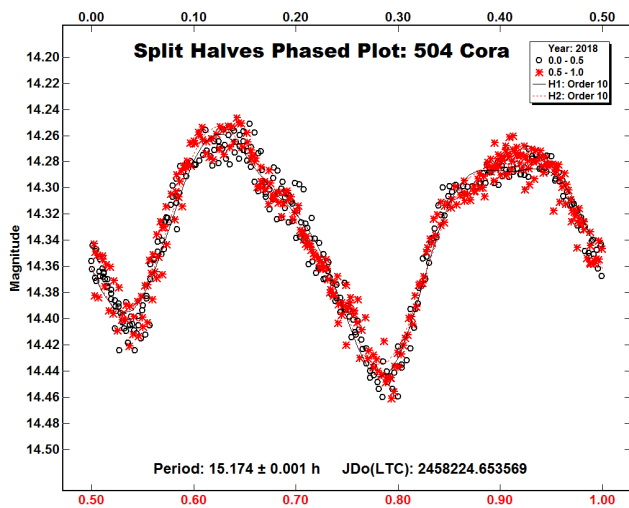


Figure 5. Split halves lightcurve of 504 Cora phased to the double period 15.174 hours.

821 Fanny. The only previously published lightcurve is for one night only and shows a period 5.44 hours, amplitude 0.01 magnitude (Behrend, 2013). New observations were obtained on 46 nights 2018 Apr. 11 – June 27. A raw lightcurve of all of these observations (Figure 6) features the usual two maxima and minima in an interval near 235 hours with amplitude near 0.22 magnitudes

in April and May increasing to near 0.28 magnitudes in June at larger phase angle. Such increase in amplitude with increasing phase angle is commonly encountered. Petr Pravec (personal communication) has examined the complete data set with simultaneous dual period software and finds no evidence of tumbling behavior above an approximate 0.04 magnitude limit of consistency of the CMC15 catalog.

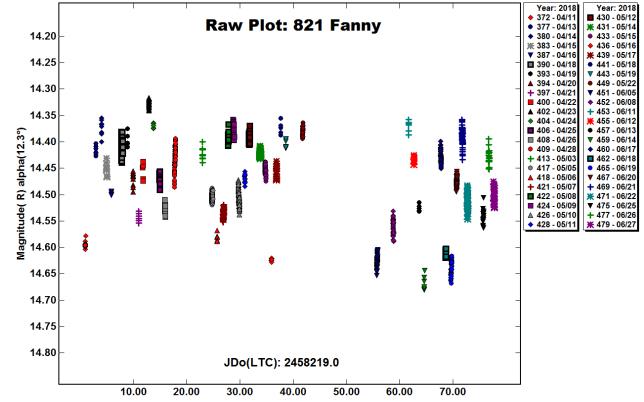


Figure 6. Raw lightcurve of 821 Fanny including all 46 sessions 2018/04/11 through 2018/06/27.

It is useful to plot separate phased lightcurves for two separate intervals. For the interval 2018 Apr. 11 – May 22, a good fit is obtained to a bimodal lightcurve (Figure 7) with synodic period 236.6 ± 0.3 hours, amplitude 0.22 ± 0.03 magnitudes. The period spectrum for this same interval is shown in Figure 8. A split halves plot for the interval Apr. 11 – May 22 (Figure 9) shows that the two sides of the 236 hour bimodal lightcurve are quite different and rules out a period near 118 hours. A split halves plot for the double period 470 hours in the same time interval (Figure 10) shows that the two sides are nearly the same and makes a period near 470 hours extremely unlikely. We may have confidence that the period is near 236 hours. For the interval 2018 June 5 – 27, a good fit is obtained to a bimodal lightcurve (Figure 11) with synodic period 230.6 ± 0.3 hours, amplitude 0.28 ± 0.03 magnitudes. The change in synodic period between these two intervals is probably due to a change in the time rate of change of phase angle bisector, but is larger than is often encountered. The night-to-night consistency of the lightcurves calibrated with CMC15 magnitudes is illustrated in raw plots of the sessions of May 9 and 10, about 6 hours each (Figure 12); and again of June 21 and 22 (Figure 13), far after opposition, where sessions were limited to less than 4 hours each as the target sank low in the sky several hours before the start of twilight.

On 2018 May 9 twenty images of exposure time 60 seconds each were obtained alternately in R and V filters and measured with the same comparison stars with their respective R and V magnitudes as derived from CMC15 catalog r' , J, Ks magnitudes. The R

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33	Polyhymnia	2018/04/10–2018/05/17	2274	7.4, 1.3, 6.1	221	-1	18.610	0.001	0.12	0.01
49	Pales	2018/04/04–2018/05/11	2376	6.0, 1.2, 5.2	214	-3	20.709	0.001	0.19	0.01
289	Nenetta	2018/05/18–2018/06/18	1403	3.4, 12.6	230	6	6.916	0.001	0.20	0.02
504	Cora	2018/04/16–2018/05/19	1817	6.9, 5.8, 9.9	216	15	7.587	0.001	0.18	0.01
821	Fanny	2018/04/11–2018/05/22	2867	12.3, 1.2, 8.8	225	2	236.6	0.3	0.22	0.03
821	Fanny	2018/06/05–2018/06/27	1401	15.2, 22.5	229	3	230.6	0.3	0.28	0.03

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first and last date, unless a minimum (second value) was reached. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984).

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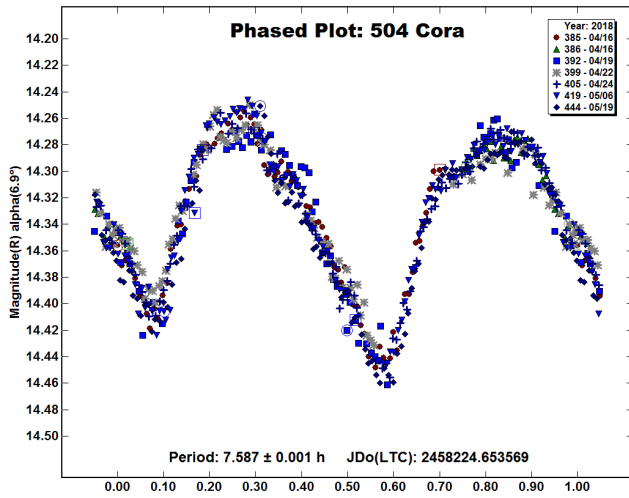


Figure 4. Phased lightcurve of 504 Cora.

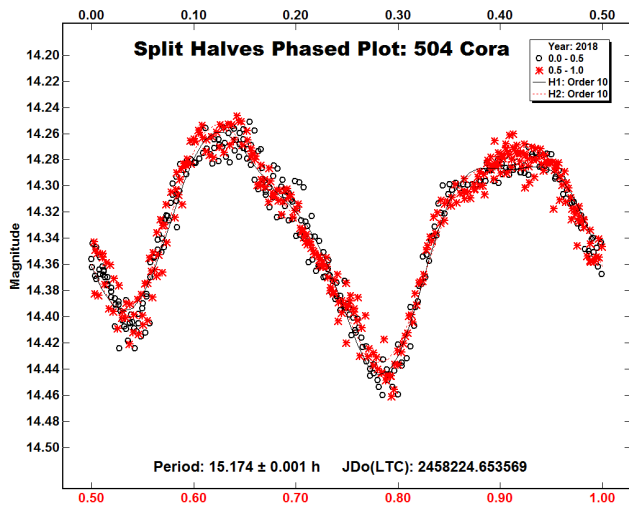


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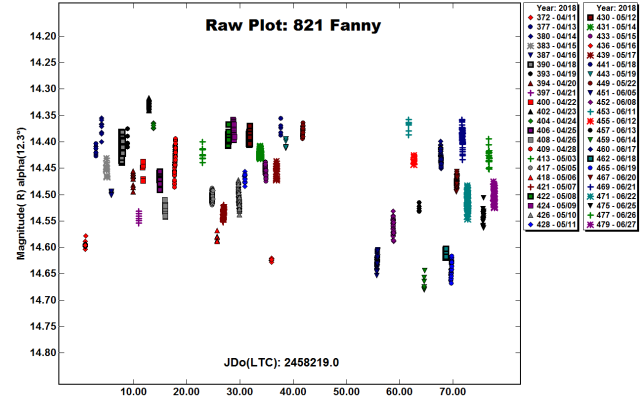


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magnitude session in the raw lightcurve plot (Figure 14) of these two sessions must be adjusted downward by 0.37 magnitudes for best overlap; hence we obtain the color index $V-R=0.37$. The R magnitudes of sessions near mid-light on the raw lightcurve are converted to V by $V-R=0.37$ and used to construct an H-G plot (Figure 15) that shows $H=11.763\pm0.018$ (in the V magnitude system) and $G=0.079\pm0.018$.

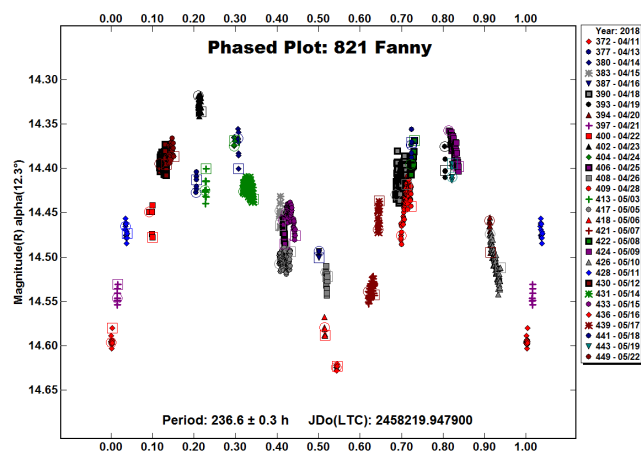


Figure 7. Phased lightcurve of 821 Fanny for the interval 2018/04/11 through 2018/05/22.

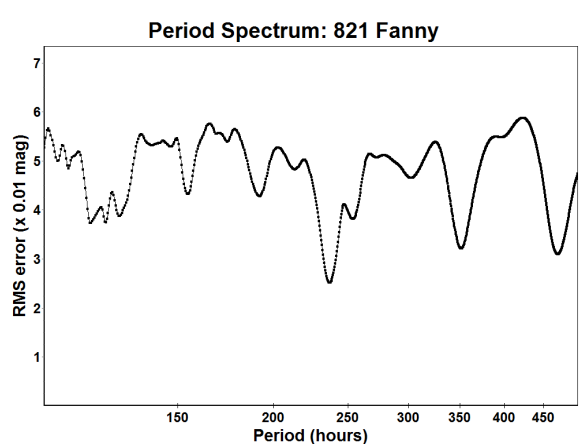


Figure 8. Period spectrum of 821 Fanny for the interval 2018/04/11 through 2018/05/22

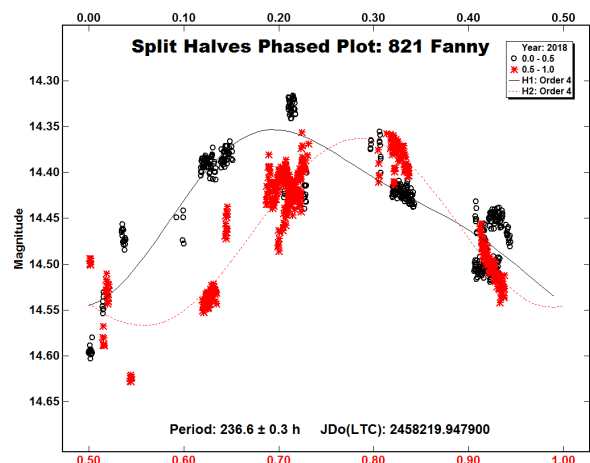


Figure 9. Split halves lightcurve for 821 Fanny for the interval 2018/04/11 through 2018/05/22.

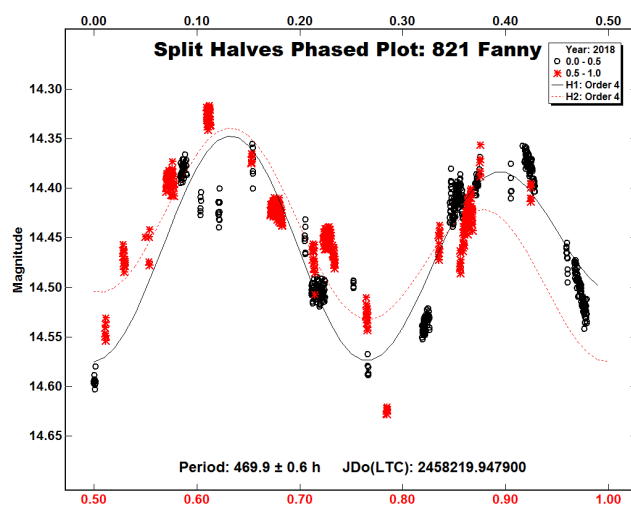


Figure 10. Split halves lightcurve for 821 Fanny for the double period 470 hours for the interval 2018/04/11 through 2018/05/22.

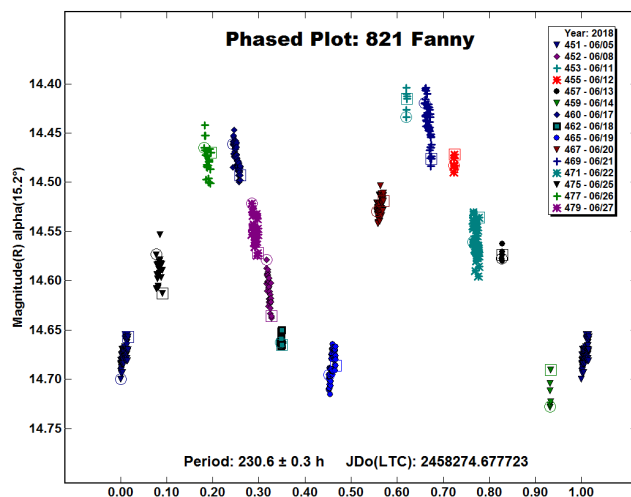


Figure 11. Phased lightcurve of 821 Fanny for the interval 2018/06/05 through 2018/06/27.

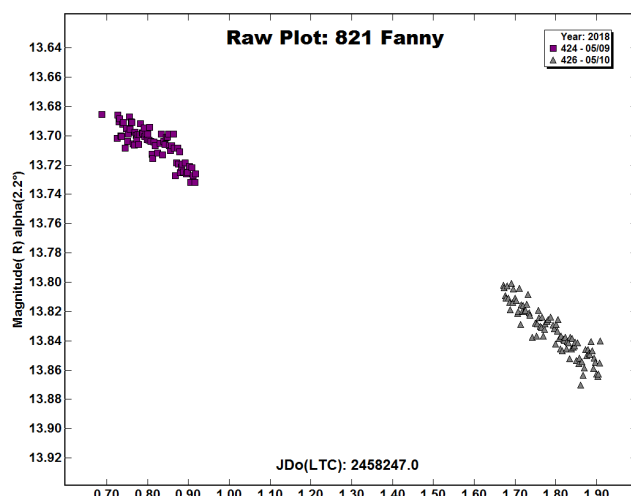


Figure 12. Raw lightcurve of 821 Fanny 2018 May 9-10.

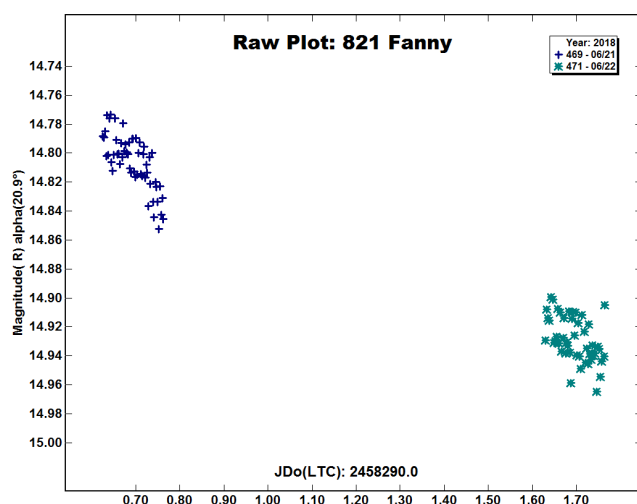


Figure 13. Raw lightcurve of 821 Fanny 2018 June 11-12.

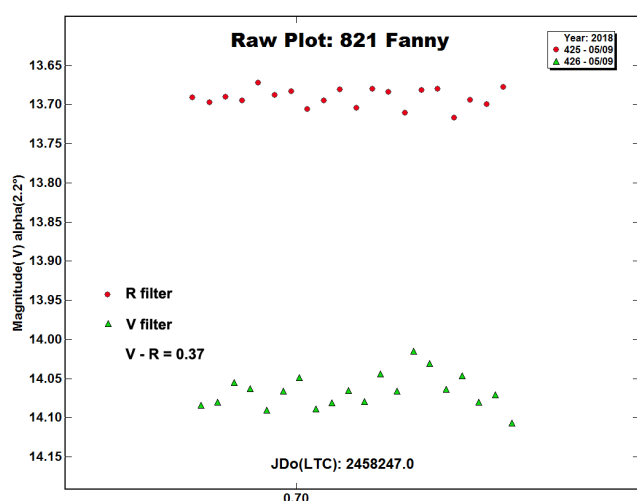


Figure 14. Raw lightcurve of R and V sessions for 821 Fanny 2018 May 9.

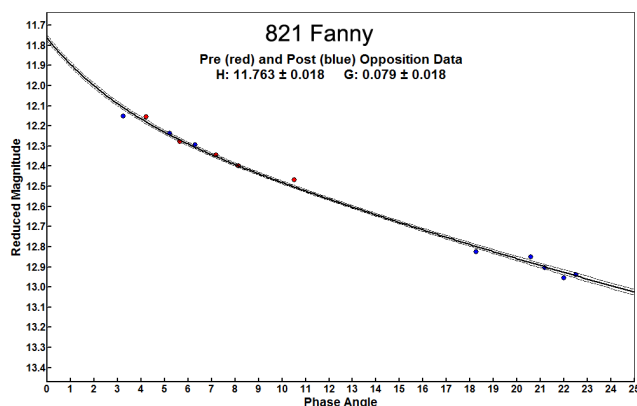


Figure 15. H-G plot for 821 Fanny in the V magnitude system.

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