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Variable Stars in Cygnus Discovered with Kourovka Planet Search. Part I: Eclipsing binaries of Algol type

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#	Name	Other	Coord (J2000)	Type	Max	Min	System	Period	Epoch (JD)	type	Sp	Comment	L.Curve	Find.Chart	Data
1		2MASS 20242458+4959020	20 24 24.59, +49 59 02.0	EA	14.80	15.06	R	2.5135	2456168.159	min		Comm. 1	TF1-00113_lc.png	TF1-00113_fc.png	TF1-00113.txt
2		2MASS 20243133+5042438	20 24 31.33, +50 42 43.8	EA	14.00	14.20	R	6.944	2456169.312	min		Comm. 2	TF1-00307_lc.png	TF1-00307_fc.png	TF1-00307.txt
3		2MASS 20250078+4938054	20 25 00.78, +49 38 05.5	EA	15.62	16.18	R	1.2803	2456124.296	min		Comm. 3	TF1-01236_lc.png	TF1-01236_fc.png	TF1-01236.txt
4		2MASS 20250871+4957141	20 25 08.71, +49 57 14.2	EA	14.43	14.58	R	0.68175	2456141.320	min		Comm. 4	TF1-01491_lc.png	TF1-01491_fc.png	TF1-01491.txt
5		2MASS 20252662+5026519	20 25 26.62, +50 26 52.0	EA	11.34	11.46	R	5.26948	2456161.481	min		Comm. 5	TF1-02042_lc.png	TF1-02042_fc.png	TF1-02042.txt
6		2MASS 20253905+5123301	20 25 39.06, +51 23 30.1	EA	14.60	14.84	R	2.996:	2456154.338	min		Comm. 6	TF1-02426_lc.png	TF1-02426_fc.png	TF1-02426.txt
7		2MASS 20254651+5023230	20 25 46.52, +50 23 23.1	EA	15.32	15.78	R		2456161.300	min		Comm. 7	TF1-02680_lc.png	TF1-02680_fc.png	TF1-02680.txt
8		2MASS 20260213+5006032	20 26 02.14, +50 06 03.2	EA	12.42	12.47	R	0.84676	2456062.817	min	G8V	Comm. 8	TF1-03154_lc.png	TF1-03154_fc.png	TF1-03154.txt
9		2MASS 20261094+5105556	20 26 10.94, +51 05 55.6	EA	15.67	16.60	R	0.546013	2456140.341	min		Comm. 9	TF1-03437_lc.png	TF1-03437_fc.png	TF1-03437.txt
10		2MASS 20264315+5123555	20 26 43.16, +51 23 55.5	EA	15.05	15.62	R	1.31336	2456131.386	min		Comm. 10	TF1-04428_lc.png	TF1-04428_fc.png	TF1-04428.txt
11		2MASS 20264501+5058461	20 26 45.02, +50 58 46.2	EA	10.91	10.97	R	5.612	2456162.260	min		Comm. 11	TF1-04470_lc.png	TF1-04470_fc.png	TF1-04470.txt
12		2MASS 20280965+5026039	20 28 09.65, +50 26 03.9	EA	13.02	13.20	R	3.84	2456131.40	min		Comm. 12	TF1-07149_lc.png	TF1-07149_fc.png	TF1-07149.txt
13		2MASS 20282625+5042557	20 28 26.25, +50 42 55.7	EA	14.40	14.92	R	1.22795	2456124.312	min		Comm. 13	TF1-07690_lc.png	TF1-07690_fc.png	TF1-07690.txt
14		2MASS 20283375+4943090	20 28 33.76, +49 43 09.0	EA	11.68	11.94	R		2456496.300	min		Comm. 14	TF1-07903_lc.png	TF1-07903_fc.png	TF1-07903.txt
15		2MASS 20284275+5056392	20 28 42.75, +50 56 39.3	EA	13.87	14.02	R	1.6476	2456160.338	min		Comm. 15	TF1-08198_lc.png	TF1-08198_fc.png	TF1-08198.txt
16		2MASS 20284845+4956372	20 28 48.46, +49 56 37.3	EA	14.42	14.58	R	5.3693	2456168.304	min		Comm. 16	TF1-08373_lc.png	TF1-08373_fc.png	TF1-08373.txt
17		2MASS 20285270+5040446	20 28 52.70, +50 40 44.7	EA	14.90	15.23	R	4.23	2456141.38	min		Comm. 17	TF1-08499_lc.png	TF1-08499_fc.png	TF1-08499.txt
18		2MASS 20290715+5115180	20 29 07.15, +51 15 18.1	EA	11.97	12.34	R	0.72057	2456134.296	min		Comm. 18	TF1-08954_lc.png	TF1-08954_fc.png	TF1-08954.txt
19		2MASS 20292815+4941172	20 29 28.16, +49 41 17.2	EA	14.80	15.42	R	2.7290	2456149.308	min		Comm. 19	TF1-09612_lc.png	TF1-09612_fc.png	TF1-09612.txt
20		2MASS 20293182+5016165	20 29 31.82, +50 16 16.6	EA	14.14	14.27	R	7.352:	2456169.354	min		Comm. 20	TF1-09724_lc.png	TF1-09724_fc.png	TF1-09724.txt
21		2MASS 20293524+4948122	20 29 35.25, +49 48 12.3	EA	13.92	14.34	R	1.00177	2456270.196	min		Comm. 21	TF1-09824_lc.png	TF1-09824_fc.png	TF1-09824.txt
22		2MASS 20295378+5013551	20 29 53.78, +50 13 55.2	EA	14.85	15.68	R	1.2713	2456124.224	min		Comm. 22	TF1-10473_lc.png	TF1-10473_fc.png	TF1-10473.txt
23		2MASS 20300448+5036253	20 30 04.49, +50 36 25.3	EA	13.28	13.67	R	1.04597	2456140.311	min		Comm. 23	TF1-10841_lc.png	TF1-10841_fc.png	TF1-10841.txt

24		2MASS 20301347+5113011	20 30 13.48, +51 13 01.2	EA	13.90	14.23	R		2456148.32	min		Comm. 24	TF1-11148_lc.png	TF1-11148_fc.png	TF1-11148.txt
25		2MASS 20311210+4937018	20 31 12.10, +49 37 01.9	EA	14.62	14.88	R	2.6490	2456272.178	min		Comm. 25	TF1-13176_lc.png	TF1-13176_fc.png	TF1-13176.txt
26		2MASS 20311925+4944187	20 31 19.25, +49 44 18.8	EA	13.87	14.02	R	2.6058	2456160.244	min		Comm. 26	TF1-13412_lc.png	TF1-13412_fc.png	TF1-13412.txt
27	V0745 Cyg	2MASS 20314369+5052133	20 31 43.70, +50 52 13.4	EA	11.88	12.28:	R	2.2831	2454298.624	min		Comm. 27	TF1-14190_lc.png	TF1-14190_fc.png	TF1-14190.txt
28		2MASS 20315610+4955072	20 31 56.11, +49 55 07.3	EA	13.75	14.00	R		2456150.3	min		Comm. 28	TF1-14601_lc.png	TF1-14601_fc.png	TF1-14601.txt
29		2MASS 20321743+5053479	20 32 17.43, +50 53 47.9	EA	12.54	12.85	R	10.899	2456375.473	min		Comm. 29	TF1-15295_lc.png	TF1-15295_fc.png	TF1-15295.txt
30		2MASS 20324567+5052056	20 32 45.68, +50 52 05.6	EA	14.64	15.38	R	1.6851	2456131.364	min		Comm. 30	TF1-16208_lc.png	TF1-16208_fc.png	TF1-16208.txt
31		2MASS 20331729+5118556	20 33 17.29, +51 18 55.7	EA	13.97	14.27	R	0.60242	2456135.400	min		Comm. 31	TF1-17274_lc.png	TF1-17274_fc.png	TF1-17274.txt
32		2MASS 20333229+5028573	20 33 32.30, +50 28 57.3	EA	13.14	13.32	R	2.2891	2456161.377	min		Comm. 32	TF1-17750_lc.png	TF1-17750_fc.png	TF1-17750.txt
33		2MASS 20335379+5035040	20 33 53.80, +50 35 04.0	EA	14.70	14.90	R	2.46:	2456169.31	min		Comm. 33	TF1-18473_lc.png	TF1-18473_fc.png	TF1-18473.txt
34		2MASS 20340397+4952136	20 34 03.98, +49 52 13.6	EA	14.16	14.61	R	0.77122	2456141.383	min		Comm. 34	TF1-18819_lc.png	TF1-18819_fc.png	TF1-18819.txt
35		2MASS 20340645+5016488	20 34 06.46, +50 16 48.8	EA	13.92	14.58	R	0.48770	2456133.395	min		Comm. 35	TF1-18913_lc.png	TF1-18913_fc.png	TF1-18913.txt
36		2MASS 20341922+4940430	20 34 19.23, +49 40 43.0	EA	15.80	16.46	R	2.6362:	2456403.401	min		Comm. 36	TF1-19369_lc.png	TF1-19369_fc.png	TF1-19369.txt
37		2MASS 20343391+5000303	20 34 33.92, +50 00 30.4	EA	16.50	18.2	R	5.5344	2456169.305	min		Comm. 37	TF1-19832_lc.png	TF1-19832_fc.png	TF1-19832.txt
38		2MASS 20344126+5111171	20 34 41.27, +51 11 17.1	EA	13.23	13.36	R	5.7:	2456403.4	min		Comm. 38	TF1-20107_lc.png	TF1-20107_fc.png	TF1-20107.txt
39		2MASS 20344804+5035109	20 34 48.04, +50 35 10.9	EA	13.97	14.82	R	5.01	2456141.39	min		Comm. 39	TF1-20328_lc.png	TF1-20328_fc.png	TF1-20328.txt
40		2MASS 20345474+5047344	20 34 54.75, +50 47 34.4	EA	16.40	18.2	R	7.14:	2456141.28	min		Comm. 40	TF1-20573_lc.png	TF1-20573_fc.png	TF1-20573.txt
41		2MASS 20345937+4942109	20 34 59.37, +49 42 10.9	EA	14.40	14.58	R		2456134.4	min		Comm. 41	TF1-20712_lc.png	TF1-20712_fc.png	TF1-20712.txt
42		2MASS 20350000+5044395	20 35 00.01, +50 44 39.6	EA	15.53	16.0	R	0.61882	2456133.376	min		Comm. 42	TF1-20734_lc.png	TF1-20734_fc.png	TF1-20734.txt
43		2MASS 20350181+4945252	20 35 01.82, +49 45 25.3	EA	13.33	13.78:	R	6.92:	2456135.99	min		Comm. 43	TF1-20787_lc.png	TF1-20787_fc.png	TF1-20787.txt
44		2MASS 20352554+5033285	20 35 25.54, +50 33 28.6	EA	15.58	15.83	R	0.991	2456161.311	min		Comm. 44	TF1-21392_lc.png	TF1-21392_fc.png	TF1-21392.txt
45		2MASS 20353462+5028218	20 35 34.63, +50 28 21.8	EA	15.17	16.2	R	1.13914	2456400.433	min		Comm. 45	TF1-21500_lc.png	TF1-21500_fc.png	TF1-21500.txt

Comments:

1. Twice longer period is also possible.

2. Twice longer period is also possible.

3. Twice longer period is also possible.

4. MinII = $14^{m}.49$.

5. MinII = $11^{m}.45$.

6. MinII = $14^{m}.79$.

7. We observed only two brightness minima.

8. Former transiting exoplanet candidate of spectral type G8V (Burdanov et al. 2013) is an eclipsing binary with secondary minimum 0.009 mag deep. A secondary eclipse was revealed during photometric follow-up observations.

9. MinII = $16^{m}.46$.

10. Twice longer period is also possible.

11. MinII = 10^{m}.95:.

12. MinII = 13^{m}.14. Combined brightness of two close stars, 2MASS J20280965+5026039 and 2MASS J20280935+5026078 (TF1-07140), was measured. The first one probably varies.

13. MinII = 14^{m}.52.

14. We observed only one decrease of brightness.

15. MinII = 13^{m}.94:. Twice longer period is also possible.

16. MinII = 14^{m}.51.

17. Twice longer period is also possible.

18. MinII = 12^{m}.05.

19. MinII = 15^{m}.19.

20. Orbital eccentricity is possible.

21. MinII = 14^{m}.13.

22. MinII = 15^{m}.41.

23. MinII = 13^{m}.46. O'Connell effect.

24. We observed only one decrease of brightness.

25. MinII = 14^{m}.85. Twice shorter period is also possible.

26. Twice longer period is also possible.

27. Twice longer period is also possible.

28. We observed only one decrease of brightness.

29. MinII = 12^{m}.71. There is an orbital eccentricity.

30. MinII = 15^{m}.18.

31. MinII = 14^{m}.18. O'Connell effect.

32. MinII = 13^{m}.21.

33. MinII = 14^{m}.83.

34. MinII = 14^{m}.57. O'Connell effect.

35. MinII = 14^{m}.49. O'Connell effect.

36. Twice longer period is also possible.

37. MinII = $17^{m}.10$:. Orbital eccentricity is possible.

38. MinII = $13^{m}.35$. There is an orbital eccentricity.

39. Twice longer period is also possible.

40. Twice longer period is also possible.

41. We observed only one decrease of brightness.

42. MinII = $15^{m}.7$.

43. MinII = $13^{m}.47$:. O'Connell effect.

44. Twice longer period is also possible.

45. MinII = $15^{m}.40$.

Remarks:

Kourovka Planet Search (KPS) is a project aimed at finding new transiting exoplanets using the Master-II-URAL telescope. Our pilot observations were obtained during short and bright summer nights of 2012 at the Kourovka Astronomical Observatory of the Ural Federal University. We observed the first 2 × 2 square degree target field in Cygnus centred at $\alpha = 20^{h}30^{m}.0$, $\delta = +50°30'.0$ (J2000.0).

Main part of observations were carried out during May–August, 2012 with additional sets in December, 2012, March–May, 2013 and July–August, 2013 with the Master-II-URAL robotic telescope.

The system consists of two parallel optical telescopes (40-cm aperture, 1:2.5 focal ratio) installed on the same mount and equipped with two Peltier cooled Apogee Alta U16M CCD cameras. The image scale is 1.85"/px. Observations can be performed simultaneously in two filters of the Johnson–Cousins BVRI photometric system (Lipunov et al. 2010).

Our main observational set lasted for 36 nights in R band with 50-second exposures. There were several additional observational nights were in December, 2012 in R and V bands with 180-second exposures. The longest additional observational set was conducted during March–May, 2013 for 16 nights in B and V bands with 120-second exposure times. We carried out our final set in 2013 July–August with 120-second exposures in V and R bands.

Astrometric reductions of all frames were performed using the Astrometry.net console application (Lang et al. 2010). All objects were identified using 2MASS catalogue (Skrutskie et al. 2006). Initial photometric reductions and aperture photometry were performed in the IRAF package (Tody 1986). We used the Astrokit console application (Burdanov et al. 2014) for data post-processing. The program performs high-precision differential CCD photometry for thousands of stars and uses Robust Median Statistic criterion (Rose & Hintz 2007) to search for variable-star candidates. The photometric precision for stars from 10 to 16 mag was 0.01–0.12 mag, 0.008–0.05 mag, and 0.007–0.09 mag for B, V, and R bands respectively.

From initial sample of 21500 stars, we selected 370 variable objects whose light curves were inspected by eye. To determine periods of variability, we used the light curve analysis tool by Kirill Sokolovsky. This application implements Lafler & Kinman (1965) and Deeming (1975) methods to search for periods as well as transforms Julian Dates to Heliocentric Julian Dates.

All variable objects were divided into five groups according to their light-curve shape: 1) Algol-type eclipsing binaries (EA); 2) β Lyrae and W Ursae Majoris eclipsing binaries (EB and EW); 3) δ Sct low-amplitude pulsating variable stars with short periods; 4) giant stars (objects with IR excess slowly changing brightness with a big amplitude) 5) all other objects that do not form any special type. We plan to publish a paper about each type of objects described before and also about validation of discovered transiting exoplanet candidates. In this paper we will discuss the first group of objects, Algol- type eclipsing binaries.

In this paper, we provide figures that consist of two panels. Star's instrumental magnitude as a function of Julian Date is given in the left panel and phase folded light curve is given in the right panel. When we could not define a period, we provide only the light curve as a function of Julian Date. In the figures, we used red colour for R band, green colour for V band, and blue colour for B band data. The B-band photometric precision is worse than in the two other filters, thus we provide it only in cases when B-band observations helped to determine the varaible's period. For the sake of visibility, we shifted stars' magnitudes in V and B bands by (V–R) and (B–R) values. Colour indices are provided on top of each figure. If there is a suspicion for a given star to have an eccentric orbit, then phase 0.5 on such light curves is marked with a vertical dashed line.

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