

Light Curves of Variable Active Galactic Nuclei from the Catalina Sky Survey

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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 00185977+0619319	00 18 59.776, +06 19 31.99	AGN	16.9	17.9	CV			other		Comm. 1	lc01.jpg	chart01.png	data01.txt
2		2MASS 00305804-1153059	00 30 58.043, -11 53 05.90	AGN	16.8	17.3	CV			other		Comm. 2	lc02.jpg	chart02.png	data02.txt
3		2MASS 01594908-0352000	01 59 49.082, -03 52 00.04	AGN	16.1	16.7	CV			other		Comm. 3	lc03.jpg	chart03.png	data03.txt
4		2MASS 02221804-0625111	02 22 18.046, -06 25 11.18	AGN	17.0	17.9	CV			other		Comm. 4	lc04.jpg	chart04.png	data04.txt
5		2MASS 07034450+5100423	07 03 44.502, +51 00 42.33	AGN	16.7	17.6	CV			other		Comm. 5	lc05.jpg	chart05.png	data05.txt
6		2MASS 07113788+2411300	07 11 37.889, +24 11 30.07	AGN	17.5	18.1	CV			other		Comm. 6	lc06.jpg	chart06.png	data06.txt
7		2MASS 07380702+2127295	07 38 07.029, +21 27 29.54	AGN	16.2	16.5	CV			other		Comm. 7	lc07.jpg	chart07.png	data07.txt
8		2MASS 07424005+3540250	07 42 40.053, +35 40 25.07	AGN	17.0	18.0	CV			other		Comm. 8	lc08.jpg	chart08.png	data08.txt
9		2MASS 08290463+0743391	08 29 04.633, +07 43 39.15	AGN	15.4	15.5	CV			other		Comm. 9	lc09.jpg	chart09.png	data09.txt
10		2MASS 08542951-0700568	08 54 29.512, -07 00 56.88	AGN	16.8	17.9	CV			other		Comm. 10	lc10.jpg	chart10.png	data10.txt
11		2MASS 09055360-0426119	09 05 53.609, -04 26 11.97	AGN	15.9	16.5	CV			other		Comm. 11	lc11.jpg	chart11.png	data11.txt
12		2MASS 09332405-2939559	09 33 24.055, -29 39 55.96	AGN	16.0	16.7	CV			other		Comm. 12	lc12.jpg	chart12.png	data12.txt
13		2MASS 10503791+1702084	10 50 37.911, +17 02 08.48	AGN	16.5	18.0	CV			other		Comm. 13	lc13.jpg	chart13.png	data13.txt
14		2MASS 11414222-0232533	11 41 42.228, -02 32 53.39	AGN	14.2	14.5	CV			other		Comm. 14	lc14.jpg	chart14.png	data14.txt
15		2MASS 14031941-2644275	14 03 19.419, -26 44 27.51	AGN	16.7	17.8	CV			other		Comm. 15	lc15.jpg	chart15.png	data15.txt
16		2MASS 15442601-2016342	15 44 26.012, -20 16 34.26	AGN	14.3	14.8	CV			other		Comm. 16	lc16.jpg	chart16.png	data16.txt
17		2MASS 16593988+5107269	16 59 39.883, +51 07 26.98	AGN	16.6	17.8	CV			other		Comm. 17	lc17.jpg	chart17.png	data17.txt
18		2MASS 17252982+3804510	17 25 29.828, +38 04 51.08	AGN	17.0	17.8	CV			other		Comm. 18	lc18.jpg	chart18.png	data18.txt

19	2MASS 17375730+3432525	17 37 57.306, +34 32 52.56	AGN	17.3	17.9	CV			other		Comm. 19	lc19.jpg	chart19.png	data19.txt
20	2MASS 20515533-2336415	20 51 55.339, -23 36 41.52	AGN	16.5	19.8	CV			other		Comm. 20	lc20.jpg	chart20.png	data20.txt
21	2MASS 21021057-0929046	21 02 10.579, -09 29 04.69	AGN	16.6	17.1	CV			other		Comm. 21	lc21.jpg	chart21.png	data21.txt
22	2MASS 21042191-0212389	21 04 21.912, -02 12 38.92	AGN	17.3	18.3	CV			other		Comm. 22	lc22.jpg	chart22.png	data22.txt
23	2MASS 21560164+1818371	21 56 01.641, +18 18 37.18	AGN	17.1	17.8	CV			other		Comm. 23	lc23.jpg	chart23.png	data23.txt
24	2MASS 21572678-0610176	21 57 26.782, -06 10 17.64	AGN	14.4	14.9	CV			other		Comm. 24	lc24.jpg	chart24.png	data24.txt
25	2MASS 22373222-0338085	22 37 32.228, -03 38 08.60	AGN	17.2	18.7	CV			other		Comm. 25	lc25.jpg	chart25.png	data25.txt
26	2MASS 23391553-2257573	23 39 15.538, -22 57 57.38	AGN	17.4	18.4	CV			other		Comm. 26	lc26.jpg	chart26.png	data26.txt

Comments:

1. J-K = 0.686 (2MASS), 1RXS J001859.8+061937, HR1 = 0.24, HR2 = 0.24, probably quasar (Flesch 2010); SDSS, Release 9: star-like object; CSS light curve: very slow variations, confirmed as quasar.
2. J-K = 1.412 (2MASS), 1RXS J003059.3-115300, HR1 = -0.41, HR2 = 0.33, 6dF J0030580-115306, z = 0.240540 (Jones, Read, Saunders et al. 2009), AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: slow variations, possible period ~2200 d, confirmed as quasar.
3. J-K = 1.728 (2MASS), 1RXS J015948.9-035206, HR1 = -0.51, HR2 = 0.00, probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka, 2010); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
4. J-K = 1.32 (2MASS), 1RXS J022218.0-062513, HR1 = -0.40, HR2 = -0.16, probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); SDSS, Release 9: star-like object; CSS light curve: very slow variations, confirmed as quasar.
5. J-K = 1.74 (2MASS), 1RXS J070344.4+510040, HR1 = 0.60, HR2 = -0.28, probably quasar (Flesch 2010); CSS light curve: very slow variations, confirmed as quasar.
6. J-K = 1.493 (2MASS), 1RXS J071136.5+241124, HR1 = 0.66, HR2 = -0.27, AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: very slow variations, confirmed as quasar.
7. J-K = 1.512 (2MASS), 1RXS J073806.9+212726, HR1 = 0.13, HR2 = -0.49, probably quasar (Flesch 2010; Abraham, Philip, Kembhavi et al. 2012), AGN candidate (Kouzuma and Yamaoka 2010); SDSS, Release 9: star-like object; CSS light curve: very slow variations, confirmed as quasar.
8. J-K = 1.616 (2MASS), 1RXS J074240.3+354023, HR1 = 0.38, HR2 = -0.07, probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
9. J-K = 0.542 (2MASS), 1RXS J082904.3+074335, HR1 = 0.54, HR2 = 0.61, probably quasar (Flesch 2010); SDSS, Release 9: star-like object; CSS light curve: slow variations, possible period ~1550 d, confirmed as quasar.
10. J-K = 1.661 (2MASS), 1RXS J085429.8-070046, HR1 = 0.57, HR2 = 0.20, probably quasar (Flesch 2010); CSS light curve: slow, irregular variations, confirmed as quasar.
11. J-K = 1.753 (2MASS), 1RXS J090553.8-042608, HR1 = -0.21, HR2 = 0.14, probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: slow, irregular variations, confirmed as quasar.

12. J–K = 1.579 (2MASS), 1RXS J093322.7–293956, HR1 = 0.80, HR2 = 0.13, AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: slow, irregular variations, confirmed as quasar.
13. J–K = 1.768 (2MASS), 1RXS J105038.2+170220, HR1 = 0.33, HR2 = 0.28, quasar or Seyfert galaxy (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010), Probably Sab or Scd galaxy (Huertas-Company, Aguerri, Bernardi et al., 2011); SDSS Release 9: galaxy; CSS light curve: irregular variations, confirmed as Seyfert 1 galaxy.
14. J–K = 0.784 (2MASS), 1RXS J114142.4–023248, HR1 = 0.44, HR2 = 0.38, quasar candidate, SDSS J114142.22–023253.4, $z = 0.325$ (Richards, Nichol, Gray et al. 2004); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
15. J–K = 1.569 (2MASS), 1RXS J140319.7–264417, HR1 = 0.53, HR2 = –0.01, quasar or Seyfert galaxy (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: slow, irregular variations, confirmed as quasar.
16. J–K = 1.328 (2MASS), 1RXS J154426.3–201637, HR1 = 0.84, HR2 = 0.27, AGN candidate (Kouzuma and Yamaoka 2010), SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
17. J–K = 1.81 (2MASS), 1RXS J165939.3+510717, HR1 = 0.01, HR2 = 0.50, probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: slow, irregular variations, confirmed as quasar.
18. J–K = 1.426 (2MASS), 1RXS J172529.7+380445, HR1 = 0.07, HR2 = –0.19, probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
19. J–K = 1.337 (2MASS), 1RXS J173757.0+343256, HR1 = –0.22, HR2 = –0.18, AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: very slow variations, confirmed as quasar.
20. J–K = 0.85 (2MASS), 1RXS J205155.5–233651, HR1 = –0.70, HR2 = 0.31; CSS light curve: slow, irregular variations, confirmed as quasar.
21. J–K = 1.423 (2MASS), 1RXS J210210.0–092914, HR1 = 0.10, HR2 = 0.18, 2MASX J21021062–0929048, type galaxy, AGN candidate (Kouzuma and Yamaoka 2010); CSS light curve: very slow variations, confirmed as quasar.
22. J–K = 0.979 (2MASS), 1RXS J210421.1–021233, HR1 = 0.71, HR2 = –0.20; SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
23. J–K = 1.688 (2MASS), 1RXS J215602.5+181839, HR1 = 0.67, HR2 = –0.04, GALEX 2665614247650660913 (quasar candidate), probably quasar (Flesch 2010), AGN candidate (Kouzuma and Yamaoka 2010); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
24. J–K = 1.443 (2MASS), 1RXS J215727.0–061022, HR1 = 0.08, HR2 = 0.67, quasar or Seyfert galaxy (Flesch 2010); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
25. J–K = 1.453 (2MASS), 1RXS J223732.3–033805, HR1 = 0.47, HR2 = 0.90, AGN candidate (Kouzuma and Yamaoka 2010); SDSS, Release 9: star-like object; CSS light curve: slow, irregular variations, confirmed as quasar.
26. J–K = 0.475 (2MASS), 1RXS J233915.2–225752, HR1 = –0.31, HR2 = –0.20, 6dF J2339155–225758, $z = 0.834777$, type: galaxy (Mahony, Croom, Boyle et al. 2010), probably quasar (Flesch 2010); CSS light curve: slow, irregular variations, confirmed as quasar

Remarks:

We present [Catalina Sky Survey](#) (CSS, Drake et al. 2009) light curves of 26 variable optical counterparts to selected sources from the ROSAT All-Sky Survey Bright Source Catalogue (Voges, Aschenbach, Boller et al. 1999), which can be identified with candidate active galactic nuclei (AGNs) from various catalogues (eg. Kouzuma and Yamaoka 2010). The sample of possible AGNs comprises of 25 likely quasars and one likely Seyfert type 1 galaxy (= No. 13, 2MASS J10503791+1702084). We confirm their AGN nature

in this work on grounds of their typical photometric variability (cf. e.g. Bauer, Baltay, Coppi et al. 2009) and their X-ray identification.

Each object was checked against the Strasbourg CDS VizieR and SIMBAD services and the NASA/IPAC Extragalactic Database for information about its nature and known optical variability. Astrometric positions were derived from the 2MASS catalogue (Skrutskie, Cutri, Stiening et al. 2006). Near-infrared colour indices from the 2MASS catalog and ROSAT All-Sky Survey Bright Source Catalogue identifications are presented in the comments. Whenever available, the source classification of the object ("Star" or "Galaxy"), which provides valuable information to distinguish star-like quasars from extended Seyfert galaxies, was derived from Data Release 9 of the SDSS Photometric Catalog (Ahn, Alexandroff, Allende Prieto et al. 2012) and included in the analysis.

We have carried out period analyses of all objects with Period04 (Lenz and Breger 2005), which reveal that the light variations of the 26 AGNs are mostly slow and irregular without any clear periodicity (17 objects). We find possible semiregular variations in two quasars (2MASS 00305804–1153059, $P \sim 2200$ d and 2MASS 08290463+0743391, $P \sim 1550$ d). However, because of the length of the periods and the comparably short time baseline of about seven years, we stress the preliminary and uncertain nature of these results, which need to be confirmed by further, long-term photometric studies. It is interesting to note, though, that similar long-period variations of AGNs are proposed in the literature (cf. e.g. Bisch, Pastoriza, Dottori, Busko 1987; Cid Fernandes, Terlevich, Aretxaga et al. 1997; Oknyanskij and Lyuty 2007).

Seven quasars vary on very long timescales during the observed timespan. For these objects, we were not able to decide between periodic or irregular behaviour because of an insufficient time baseline. The corresponding quasars were tagged with "very slow variations" in the remarks. The observed, mostly irregular variations of the quasars and the Seyfert galaxy are in line with observational evidence presented in other publications (e.g. Vanden Berk, Wilhite, Kron et al., 2004; Cioni, Kamath, Rubele et al., 2012).

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References:

- Abraham, S., Philip, N.S., Kembhavi, A., et al., 2012, *Mon. Not. Royal Astron. Soc.*, 419, 80
Ahn, C.P., Alexandroff, R., Allende Prieto, C., et al., 2012, *Astrophys. J. Suppl.*, 203, 21
Bauer, A., Baltay, C., Coppi, P., et al., 2009, *Astrophys. J.*, 696, 1241
Bisch, S.M., Pastoriza, M.G., Dottori, H., Busko, I., 1987, *Internat. Astron. Union Symp. Proceedings*, 121, 185
Cid Fernandes, R. Jr., Terlevich, R., Aretxaga, I., 1997, *Mon. Not. Royal Astron. Soc.*, 289, 318
Cioni, M.-R. L., Kamath, D., Rubele, S., et al., 2013, *Astron. and Astrophys.*, 549, A29
Drake, A.J., Djorgovski, S.G., Mahabal, A., et al., 2009, *Astrophys. J.*, 696, 870
Flesch, E., 2010, *Publ. Astron. Soc. Australia*, 27, 283
Huertas-Company, M., Aguerri, J.A.L., Bernardi, M., et al., 2011, *Astron. and Astrophys.*, 525, 157
Jones, D.H., Read, M.A., Saunders, W. et al., 2009, *Mon. Not. Royal Astron. Soc.*, 399, 683
Kouzuma, S., Yamaoka, H., 2010, *Mon. Not. Royal Astron. Soc.*, 405, 2062
Lenz P., Breger M. 2005, *Communications in Asteroseismology*, 146, 53
Mahony, E.K., Croom, S.M., Boyle, B.J., et al., 2010, *Mon. Not. Royal Astron. Soc.*, 401, 1151
Oknyanskij, V., Lyuty, V., 2007, *Perem. Zvezdy Prilozh.*, 7, 28
Richards, G.T., Nichol, R.C., Gray, A.G., et al., 2004, *Astrophys. J. Suppl.*, 155, 2, 257
Skrutskie, M.F., Cutri, R.M., Stiening, R., et al., 2006, *Astron. J.*, 131, 1163
Vanden Berk, D.E., Wilhite, B.C., Kron, R.G., et al., 2004, *Astrophys. J.*, 601, 692
Voges, W., Aschenbach, B., Boller, Th., et al., 1999, *Astron. and Astrophys.*, 349, 389