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COMPARISON AND CONTROL STARS AROUND QUASARS SUITABLE FOR THE ICRF – GAIA CRF LINK

MILJANA D. JOVANOVIĆ[1], GORAN DAMLJANOVIĆ[1] and FRANÇOIS TARIS[2]

[1]*Astronomical observatory, Volgina 7, 11060 Belgrade, Serbia*
[2]*Observatoire de Paris - SYRTE, 61 av. de l'Observatoire, 75014 Paris, France*
E-mail: miljana@aob.rs, gdamljanovic@aob.rs, francois.taris@obspm.fr

Abstract. To link International and Gaia Celestial Reference Frame is necessary to observe and monitor set of sources visible in radio and optical wavelengths. From 2013 until 2019, we observed 47 active galactic nuclei (AGNs) which are candidate sources for the link between the frames. Our observations, in optical V and R bands were performed using eight telescopes from Serbia, Spain, Bulgaria, and Austria. The brightness of the sources and control stars were determined by differential photometry using suitable comparison stars. The obtained light curves of sources are significant for the understanding of the physical processes inside them. We tested the brightness in V, and R bands, and V-R colour (of sources, and their comparison, and control stars) with two statistical tests (Abbe's criterion, and F test), and some results are presented here.

1. INTRODUCTION

The third data release of Gaia mission - Gaia DR3 (Gaia Collaboration, Vallenari, A. et al. (2022)) is made public available, since 13 June 2022, and it is based on data collected between 25 July 2014, and 28 May 2017. The reference epoch for Gaia DR3 is 2016.0. The set of Gaia Early Data Release 3 is complemented with: object classifications for about 1.8 billion sources, astrophysical parameters for ~5.5 million objects, radial velocities for ~33 million stars, variability analysis, together with the epoch photometry for ~10.5 million sources, etc. The Gaia celestial reference frame 3 is based on the observations of quasi-stellar objects (QSOs) at optical wavelength. It could be linked with the International Celestial Reference Frame 3 (Charlot et al. (2020)) using a set of QSOs visible in the optical and radio domains. In paper Bourda et al. (2011) 47 active galactic nuclei (AGNs) were suggested for that link. We observed those AGNs from 2013 to 2016, and tested their brightness (calculated using stars from their vicinity). The results for the five most observed sources were published in paper Jovanović (2019). We analysed the britghness of 7 more sources, and in this paper we present the results of investigation of brightness variability of their comparison, and control stars. Three sources are flat spectrum radio quasars - FSRQs (0049+003, 1212+467, and 1612+378), three are BL Lacertae - BL Lac (0907+336, 1034+574, and 1242+574), and one (1429+249) has dual nature of FSRQ, and BL Lac. The sources redshifts z are: 0049+003 z=0.40, 0907+336 z=0.35, 1034+574 z=1.10, 1212+467 z=0.72, 1242+574 z=1.00, 1429+249 z=0.41, and 1612+378 z=1.53. Also, in this paper are given finding charts for all sources and comparison and control stars.

2. OBSERVATIONS

The observations were carried out with eight telescopes, two at Astronomical Station Vidojevica (ASV) of Astronomical Observatory of Belgrade, Serbia; Joan Oró telescope (TJO) at the Montsec Astronomical Observatory, Catalonia, Spain; three at Rozhen, NAO, Bulgaria, one in Belogradchik, Bulgaria; and one telescope at Leopold Figl at Vienna, Austria. The details about these telescopes, their mirror aperture, mounted CCD cameras and optical filters are presented in paper Jovanović et al. 2021.

Two or more CCD images were obtained in V and R bands except when observations were done using TJO telescope, only one CCD image frame was taken in V and R bands. The image reduction was performed using advance image calibration in IRAF scripting language (ascl:9911.002)(Tody 1986, 1993). Bias, dark, and flat-field frames obtained for the same observing nights, are used for reduction, and for the bad pixel mapping (hot, and dead pixel map). L.A.Cosmic method by Pieter G. van Dokkum was used for the corrections for cosmic rays (van Dokkum, 2001).

We determined the brightness of the sources and control stars using differential photometry with Maxim DL software, with two or more comparison stars. The comparison and control stars were selected from the Sloan Digital Sky Survey Data Release 14 (SDSS DR14) catalogue (Abolfathi et al. 2018). Using the equations given by Chonis & Gaskell (2008) the SDSS PSF ugriz (point spread function u, g, r, i, and z) magnitudes were transformed into V, and R magnitudes

$$V = g - (0.587 \pm 0.022)(g - r) - (0.011 \pm 0.013),$$

$$R = r - (0.272 \pm 0.092)(r - i) - (0.159 \pm 0.022).$$

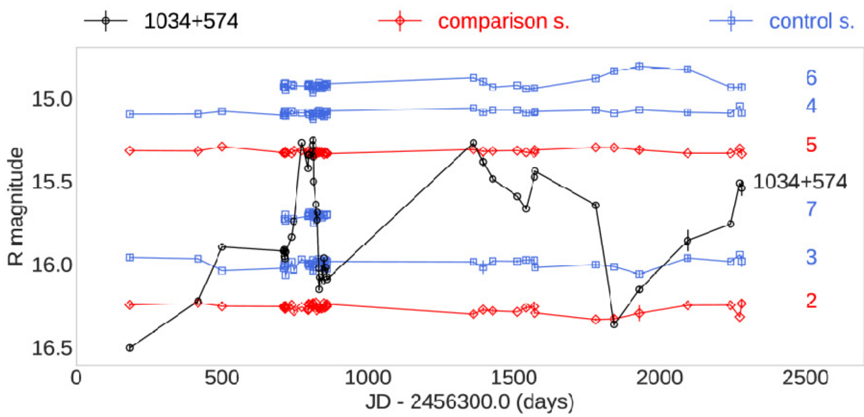

Figure 1: The light curves of 1034+574 (circles connected with lines), its comparison (diamonds connected with lines), and control stars (squares connected with lines).

The limits for *g, r*, and *i* magnitudes are 14.5 and 19.5 mag, for colour *r-i* are *0.08,* and *0.5* mag*,* and for colour *g-r* are 0.2, and 1.4 magnitudes. We chose comparison and control stars from the vicinity of the sources, the magnitudes of which satisfy these criteria and the colour is similar to the colour of the source.

In Table 1. are details of sources and their comparison (marked with *A* and *B*) and control stars: coordinates, the V_C and R_C magnitudes of stars (obtained using mentioned equations), V_O and R_O (average magnitudes from our observations), with number of observations N_{Vo} (in *V)*, and N_{Ro} (in *R band)*. The input magnitudes for differential photometry (V_C and R_C magnitudes of stars) and calculated magnitudes V_O and R_O (from our observations) are within the error limits. The standard deviations of control stars have the same order of magnitudes as comparison ones.

An example of light curve, 1034+574 in R band during observational period, is presented in Fig. 1 with light curves of its comparison (number 2, and 5) and control stars (3, 4, 6, and 7). The light curve of source is marked with circles connected with lines, of its comparison stars with diamonds connected with lines, and of its control stars with squares connected with lines. The blazar brightness is variable unlike the brightness of comparison and control stars. The light curve of the control star with number 6 shows variability, and this is probably because the star was on edge of field of view (star with number 7 was not on each of the ccd images that were taken). Brightness of the blazar changed by more than 1 magnitude within this period. This blazar shows short-term variability, which is visible in TJO data.

The fields of view of 7 sources with its comparison and control stars are presented in Fig. 2. The source is marked with number 1, and the stars with remaining numbers. All fields of view are about 16'x16' obtained using 60 cm telescope at ASV with Apogee Alta U 42 CCD camera.

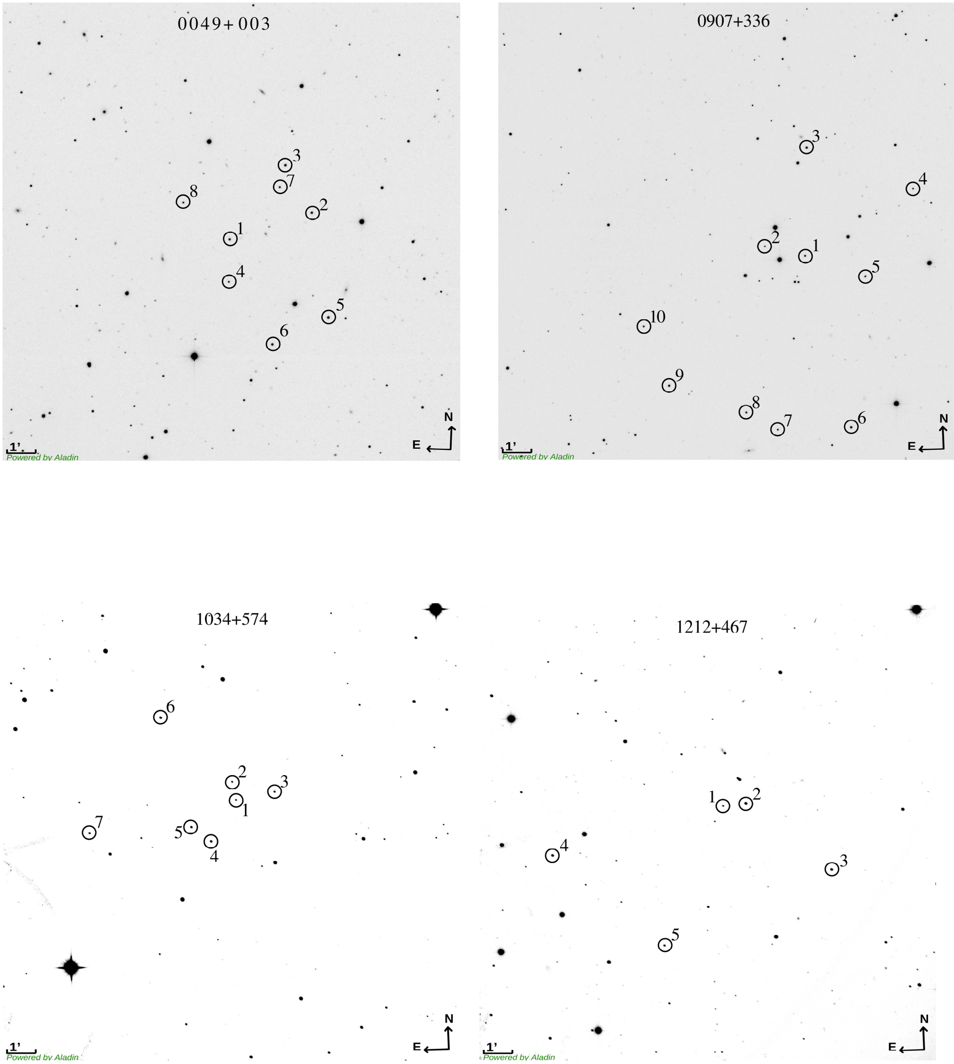

Figure 2: Fields of view of sources: 0049+003, 0907+336, 1034+574, 1212+467, 1242+574, 1429+249, and 1612+378

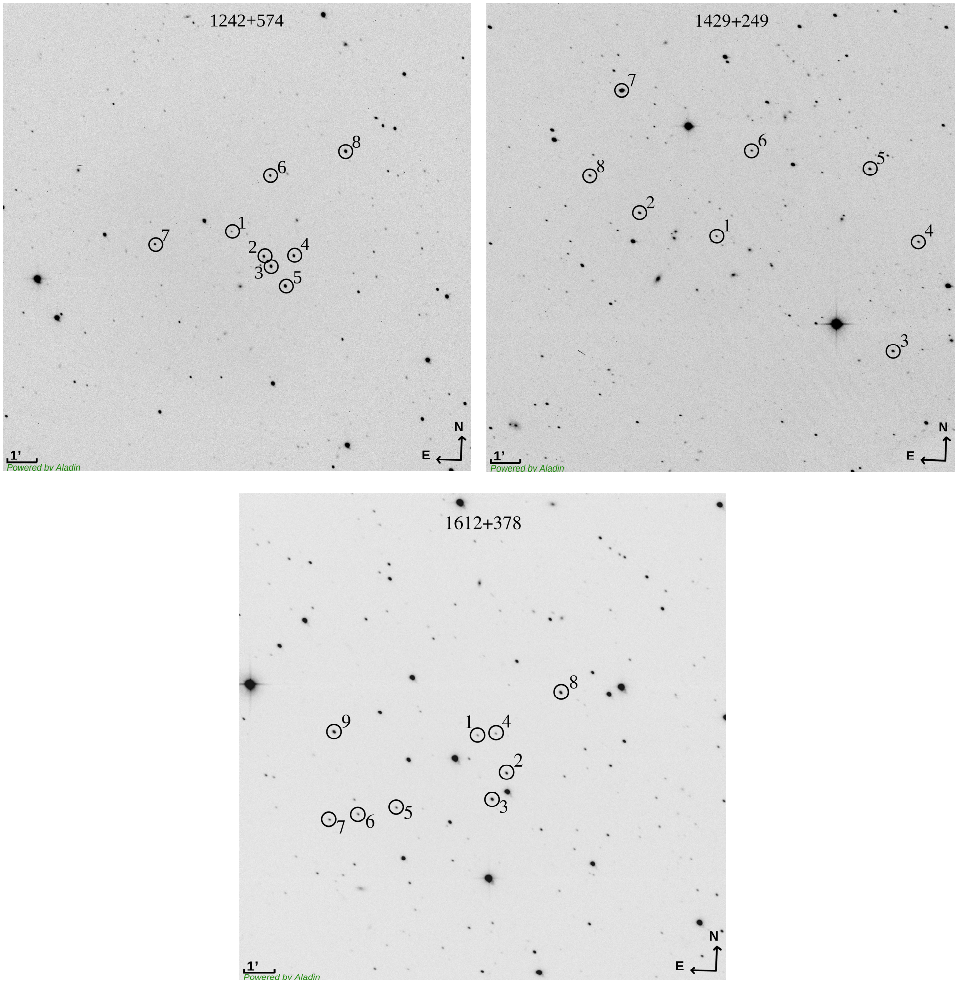

Figure 2: continued.

We compared our data to the data from Gaia Data release 3 (Gaia DR3). We calculated G_C for the stars with equation given by Satoretti et al. (2022) using our data in V, and R bands

$$Gc = V - 0.03088 - 0.04653(V - R) - 0.8794(V - R)^2 + 0.1733(V - R)^3, \sigma = 0.0352$$

and compare it with G magnitude given in Gaia DR3.

We presented in Fig 3. the data for the stars (comparison and control) of 12 sources (7 presented here, and 5 in paper Jovanović et al. (2021). Coefficients of linear fit (intercept=0.082, and slope=0.9960) were estimated using the weighted least square method. The Pearson linear correlation coefficient is r=0.9991, and null hypothesis probability is very close to 0. With the slope and Pearson's coefficient around 1, and calculated probability it is shown that there is a correlation between our calculated and G magnitudes from the DR3 catalogue.

Table 1: Coordinates, *V* and *R* magnitudes of comparison and control stars in the fields of sources

Object № star	$\alpha_{J2000.0}$ (°)	$\delta_{J2000.0}$ (°)	$V_C \pm \sigma_{V_C}$ (mag)	$R_C \pm \sigma_{R_C}$ (mag)	$V_O \pm \sigma_{V_O}$ (mag)	N_{V_O}	$R_O \pm \sigma_{R_O}$ (mag)	N_{R_O}
0049+003	13.02321	0.593930						
2^A	12.97558	0.60950	16.721 ± 0.039	15.830 ± 0.068	16.715 ±0.026	30	15.835 ±0.013	40
3^B	12.99098	0.63657	16.303 ± 0.036	15.680 ± 0.042	16.307 ±0.018	30	15.673 ±0.010	40
4	13.02369	0.56957	17.253 ± 0.030	16.859 ± 0.033	17.265 ±0.075	26	16.876 ±0.049	36
5	12.96617	0.54902	16.367 ± 0.038	15.547 ± 0.053	16.333 ±0.044	20	15.509 ±0.034	27
6	12.99846	0.53368	16.821 ± 0.039	15.914 ± 0.067	16.796 ±0.043	15	15.902 ±0.022	24
7	12.99423	0.62415	16.988 ± 0.026	16.655 ± 0.027	16.973 ±0.060	26	16.637 ±0.035	36
8	13.05000	0.61540	17.392 ± 0.034	16.804 ± 0.040	17.402 ±0.063	26	16.795 ±0.049	35
0907+336	137.65431	33.49012						
2^A	137.68218	33.49568	16.947 ± 0.027	16.493 ± 0.032	16.983 ±0.041	39	16.535 ±0.031	42
3^B	137.65315	33.55212	15.152 ± 0.025	14.765 ± 0.029	15.143 ±0.010	36	14.755 ±0.009	39
4	137.57933	33.52884	16.754 ± 0.023	16.402 ± 0.029	16.727 ±0.048	37	16.392 ±0.045	38
6	137.62254	33.39133	15.595 ± 0.036	14.787 ± 0.053	15.664 ±0.019	14	14.816 ±0.011	14
7	137.67337	33.39007	16.600 ± 0.031	15.964 ± 0.042	16.673 ±0.029	13	15.998 ±0.014	13
8	137.69512	33.40002	15.840 ± 0.024	15.596 ± 0.025	15.841 ±0.040	14	15.581 ±0.026	14
9	137.74861	33.41535	15.412 ± 0.028	14.910 ± 0.031	15.439 ±0.021	11	14.920 ±0.011	11
10	137.76623	33.44946	16.320 ± 0.028	15.817 ± 0.033	16.349 ±0.024	5	15.831 ±0.025	5
1034+574	159.43461	57.19878						
2^A	159.43831	57.20934	16.764 ± 0.028	16.252 ± 0.036	16.770 ±0.025	47	16.262 ±0.024	47
5^B	159.48269	57.18367	15.874 ± 0.029	15.329 ± 0.040	15.872 ±0.011	47	15.323 ±0.011	47
3	159.39357	57.20304	16.654 ± 0.032	15.993 ± 0.046	16.662 ±0.041	47	15.999 ±0.027	47
4	159.46188	57.17536	15.714 ± 0.031	15.103 ± 0.042	15.708 ±0.024	47	15.088 ±0.014	47
6	159.51361	57.24663	15.351 ± 0.027	14.904 ± 0.034	15.349 ±0.048	41	14.918 ±0.032	41
7	159.59133	57.18112	16.480 ± 0.038	15.688 ± 0.056	16.509 ±0.035	25	15.709 ±0.016	24
1212+467	183.79143	46.45420						
3^A	183.70101	46.41680	16.053 ± 0.028	15.760 ± 0.030	16.036 ±0.020	49	15.749 ±0.020	49
2^B	183.77226	46.45566	15.782 ± 0.029	15.445 ± 0.032	15.802 ±0.017	50	15.460 ±0.019	50
4	183.93530	46.42732	16.455 ± 0.033	16.089 ± 0.035	16.404 ±0.029	16	16.036 ±0.021	16
5	183.84232	46.37444	17.171 ± 0.031	16.715 ± 0.035	17.124 ±0.057	25	16.671 ±0.047	25
1242+574	191.29167	57.16510						
3^A	191.25047	57.14550	15.605 ± 0.036	15.123 ± 0.031	15.620 ±0.012	49	15.138 ±0.008	57
6^B	191.25146	57.19683	16.806 ± 0.034	16.428 ± 0.032	16.770 ±0.029	43	16.383 ±0.022	51
2	191.25798	57.15121	16.184 ± 0.035	15.773 ± 0.031	16.186 ±0.021	49	15.781 ±0.023	57
4	191.22685	57.15156	15.837 ± 0.034	15.462 ± 0.029	15.840 ±0.023	49	15.459 ±0.017	57
5	191.23555	57.13461	15.190 ± 0.031	14.790 ± 0.029	15.146 ±0.018	49	14.761 ±0.016	56
7	191.37149	57.15773	16.593 ± 0.039	16.227 ± 0.029	16.559 ±0.026	42	16.192 ±0.033	50
1429+249	217.85787	24.70575						
2^A	217.90576	24.71909	16.336 ± 0.034	15.778 ± 0.039	16.340 ±0.028	40	15.787 ±0.032	44
6^B	217.83619	24.75416	17.459 ± 0.032	17.019 ± 0.033	17.449 ±0.037	33	16.991 ±0.031	37
3	217.74829	24.64108	16.622 ± 0.033	16.102 ± 0.039	16.586 ±0.038	29	16.053 ±0.054	29
4	217.73247	24.70287	17.391 ± 0.028	17.042 ± 0.032	17.373 ±0.065	20	16.988 ±0.057	21
5	217.76278	24.74408	16.377 ± 0.032	15.999 ± 0.030	16.344 ±0.039	32	15.973 ±0.047	32
8	217.93664	24.73984	16.753 ± 0.031	16.378 ± 0.031	16.712 ±0.031	28	16.340 ±0.036	28
1612+378	243.69564	37.76869						
4^A	243.68317	37.76964	17.007 ± 0.032	16.489 ± 0.041	17.020 ±0.032	31	16.515 ±0.022	36
2^B	243.67568	37.74841	15.529 ± 0.028	15.225 ± 0.033	15.530 ±0.014	37	15.223 ±0.018	42
3	243.68553	37.73414	15.096 ± 0.029	14.739 ± 0.034	15.082 ±0.012	37	14.722 ±0.022	42
5	243.75125	37.72934	16.433 ± 0.029	16.070 ± 0.034	16.407 ±0.039	37	16.024 ±0.048	42
8	243.63855	37.79195	15.039 ± 0.030	14.627 ± 0.035	15.033 ±0.032	31	14.609 ±0.038	36

Notes. $^{(A)}$ Refers to comparison star A. $^{(B)}$ Refers to comparison star B.

In Gaia DR3 catalogue two stars are marked with variability flag, C_2 of 1722+119 and the star with number 5 of object 1242+574. The C_2 was marked as variable also in paper Doroshenko et al. (2014). With magnitude less than 13 mag it is the brightest star from our list. For star number 5 we did not find signs of variability, and the star is close to the fitting line (calculated value and given from catalogue are similar). For the stars which are distant from the fitting line, we have small number of observations.

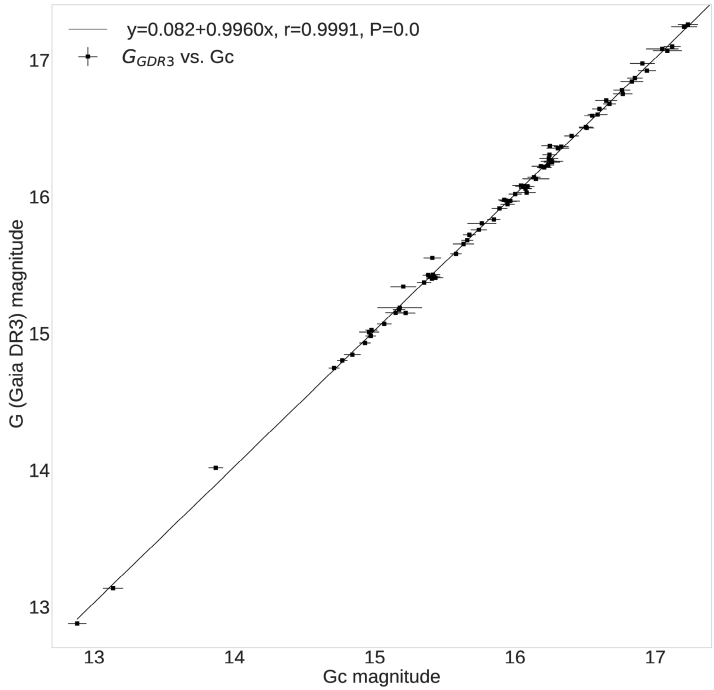

Figure 3: The linear fit of G magnitudes (Gaia DR3 vs calculated).

3. ANALYSIS METHODS AND RESULTS

To investigate variability in the control stars, we performed two statistics: Abbé's criterion and F-test. We consider that the stars are variable if the variability is detected by both tests. The tests require normal distribution of data, for that reason we applied 3-σ rule and Shapiro-Wilk test of normality (Razali et al. 2011). We discarded some of the data and concluded that the statistical methods can be applied.

Abbé's criterion is used for checking the absence of systematic changes in tested brightness. The statistic q is defined as the ratio of the Allan variance σ_{AV}, and unbiased sample variance $\sigma_{D,}$

$$q = \frac{\sigma_{AV}}{\sigma_D} = \frac{\frac{1}{2(n-1)} \sum_{i=1}^{n-1} (x_{i+1} - x_i)^2}{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2} = \frac{1}{2} \frac{\sum_{i=1}^{n-1} (x_{i+1} - x_i)^2}{\sum_{i=1}^{n} (x_i - \bar{x})^2}$$

where $\bar{x}$ is the mean value of the magnitudes. The critical point q_C is

$$q_c = 1 + u_\alpha / \sqrt{n + 0.5(1 + u_\alpha)^2}$$

where u_α is quantile of normal distribution for the significance level α. If q is lower than critical q_C, the elements of the sample cannot be accepted as random and independent. We calculate Abbé's statistics q_A, and q_B for two data sets: differences of magnitudes of control stars, and comparison stars A, and B, for the significance level α=0.001. Also we implement the Abbe statistic to the sample of brightness of comparison stars.

Also, we used F - test to determine brightness variability as in papers de Diego (2010), Jovanović (2019). The test statistic is

$$F = \frac{VarX}{VarY}\cdot$$

The H_0: *Var X*=*Var Y* is tested hypothesis, and *H*: *Var X*>*Var Y* is alternative. We calculated three test statistics:

F_1 - where X is sample of differences of magnitudes of control stars and comparison star A, and Y sample of differences of magnitudes of control stars and comparison star B,

F_2 - where X is sample of differences of magnitudes of control stars and comparison star A, and Y is sample of differences of magnitudes of comparison star A and B,

F_3 - where X is sample of differences of magnitudes of control stars and comparison star B, and Y is sample of differences of magnitudes of comparison star A and B. The statistics F_1 is F_2 divided by F_3 and should be ~1, we expect that the brightness should be variable in the same manner (for both comparison stars A, and B). The three $F_{1,2,3}$ statistics are compared with the critical values F_c for he significance level 0.001, and number of freedom n-1, where n is the sample size. The hypothesis of non variability is discarded when F_1, and F_2 are greater than F_c.

The results of Abbé's criterion and F – statistics for control stars of sources are presented in Table 2. Four comparison stars have Abe statistics lower than the critical: star with number 3 of 1242+574 in V, and stars 3 of 0049+003, 3 0907+336, 2 1612+ 378 in R band. The variations of brightness of these stars are small, the standard deviation are 0.012, 0.010, 0.009, and 0.018, respectively.

Table 2: Statistical results of stars variability

star	n	Abbé's criterion q_A, q_B, q_c	F–test F_1, F_2, F_3, F_c	star	n	Abbé's criterion q_A, q_B, q_c	F–test F_1, F_2, F_3, F_c
		V band				R band	
			0049+003				
4	26	0.79 0.77 0.45	1.03 2.88 2.80 1.96	4	36	0.57 0.67 0.52	1.11 6.03 5.42 1.76
5	20	0.87 0.36 0.39	1.48 1.01 1.50 2.17	5	27	0.47 0.39 0.46	1.95 1.91 3.73 1.93
6	15	0.83 0.83 0.33	1.11 1.25 1.12 2.48	6	24	0.89 0.46 0.43	1.48 1.04 1.55 2.01
7	26	0.42 0.53 0.45	1.84 2.60 1.41 1.96	7	36	0.38 0.65 0.52	1.81 3.86 2.13 1.76
8	26	0.87 0.76 0.45	1.29 2.41 1.86 1.96	8	35	0.58 0.69 0.51	1.18 5.91 5.02 1.77
			0907+336				
4	34	1.08 1.26 0.51	1.79 2.22 1.24 1.79	4	35	1.34 1.31 0.51	1.84 2.70 1.46 1.77
6	14	1.38 1.23 0.31	1.40 1.43 2.01 2.58	6	14	1.20 1.01 0.31	4.11 1.12 4.59 2.58
7	13	0.73 0.87 0.29	2.43 2.87 1.18 2.69	7	13	0.39 0.51 0.29	3.01 1.12 3.36 2.69
8	14	1.14 1.24 0.31	1.21 2.78 2.30 2.58	8	14	1.23 1.30 0.31	1.71 1.84 1.08 2.58
9	11	0.76 0.71 0.26	1.05 1.80 1.89 2.98	9	11	1.00 0.44 0.26	4.23 1.04 4.38 2.98
			1034+574				
3	47	0.82 0.82 0.57	1.55 2.00 1.29 1.63	3	47	0.79 0.95 0.57	1.16 1.15 1.33 1.63
4	47	0.88 0.63 0.57	2.49 1.48 3.67 1.63	4	47	0.61 0.78 0.57	6.64 1.04 6.92 1.63
6	41	0.73 0.55 0.55	1.15 1.96 1.71 1.69	6	41	0.37 0.49 0.55	1.67 2.19 1.31 1.69
7	25	0.77 0.99 0.44	1.06 1.31 1.39 1.98	7	24	0.81 0.66 0.43	1.47 1.04 1.53 2.01
			1212+467				
4	16	1.19 0.90 0.34	1.78 2.23 3.98 2.40	4	16	1.32 0.58 0.34	1.18 1.76 1.49 2.40
5	25	1.16 0.99 0.44	1.12 4.07 3.64 1.98	5	25	0.87 0.84 0.44	1.98 2.83 1.43 1.98
			1242+574				
2	43	0.81 0.57 0.56	3.88 3.92 1.01 1.67	2	51	0.64 0.45 0.59	1.12 1.85 1.66 1.60
4	43	1.09 0.95 0.56	2.95 3.69 1.25 1.67	4	51	0.71 0.60 0.59	2.31 2.96 1.28 1.60
5	43	0.54 0.84 0.56	3.41 4.76 1.40 1.67	5	50	0.64 0.73 0.58	2.80 3.16 1.13 1.61
7	42	0.92 1.00 0.55	1.72 1.88 1.10 1.68	7	50	0.86 0.95 0.58	1.16 1.53 1.78 1.61
8	41	0.26 0.39 0.55	1.01 2.70 2.67 1.69	8	47	0.20 0.33 0.57	1.46 6.76 4.63 1.63
			1429+249				
3	22	0.29 0.58 0.41	1.17 1.23 1.44 2.08	3	22	0.35 0.59 0.41	1.78 1.30 2.30 2.08
4	14	1.02 0.90 0.31	1.19 2.44 2.91 2.58	4	15	0.84 1.01 0.33	1.76 1.21 2.13 2.48
5	25	0.97 0.65 0.44	1.94 2.33 1.20 1.98	5	25	0.55 0.72 0.44	1.14 1.40 1.60 1.98
8	28	0.85 0.73 0.46	1.37 2.23 1.63 1.90	8	28	0.80 0.81 0.46	1.08 1.84 1.71 1.90
			1612+378				
3	31	0.88 0.51 0.49	8.16 1.16 9.47 1.84	3	36	0.56 0.62 0.52	1.22 1.88 2.29 1.76
5	31	0.91 0.79 0.49	1.12 1.44 1.62 1.84	5	36	0.44 0.44 0.52	2.04 4.28 2.10 1.76
8	31	0.73 0.34 0.49	1.17 1.19 1.39 1.84	8	36	0.42 0.50 0.52	1.91 3.18 1.66 1.76

4. CONCLUSIONS

We monitor (for six years) flux changes of AGNs in V, and R bands. The accuracy of differential photometry will be improved by adding more non-variable stars in calculations. For that reason we tested comparison and control stars from the objects vicinity. The tests show that most of the comparison and control stars are useful for differential photometry and only one star with number 8 of source 1242+574 is variable. We compare our data with data from Gaia DR3 catalogue, using equations to transform our V, and R magnitudes to G. We performed least square fit to the data and found good correlations between the data from Gaia DR3 catalogue and our data. The two stars are flagged as variable in Gaia DR3 catalogue. One of them (C_2 - 1722+119) very bright star with brightness of about 13 mag was also flagged as variable in paper Doroshenko et al. (2014). The second one (5 – 1242+574) is located close to the fitting line and tests did not show its variability. The V_O, and R_O magnitudes of stars (observed) and magnitudes which were the initial values for the differential photometry V_C, and R_C are in good agreement (see Table 1). We will continue with observations and investigations of Intra Day, Short Term, and Long Term changes in brightness of stars and objects.

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References

Abolfathi B., Aguado D. S., Aguilar G. et al.: 2018, *Astrophys. J., Suppl. Ser.*, 235, 42.
Bourda G., Collioud A., Charlot P., Porcas R., Garrington S.: 2011, *Astron. Astrophys.*, 526, A102.
Charlot P., Jacobs C. S., Gordon D. et al.: 2020, *Astron. Astrophys.*, 644, A159.
Chonis T. S., Gaskel M. C.: 2008, *Astron. J.*, 135, 264.
De Diego J. A.: 2010, *Astron. J.*, 139, 1269.
Doroshenko V. T., Efimov Yu. S., Borman G. A., Pulatova N. G.: 2014, *Astrophysics*, 57, 176.
Gaia Collaboration, Vallenari A., Brown A. G. A., et al. 2022, arXiv:2208.00211.
Jovanović M. D.: 2019, *Serb. Astron. J.,* 199, 55.
Jovanović M. D., Damljanović G., Taris F.: 2021, Control stars around quasars suitable for the ICRF – GAIA CRF link, *Publ. Astron. Obs. Belgrade,* No. 100, 253–258.
Razali N. M., Wah Y. B.: 2011, *Journal of Statistical Modeling and Analytics,* 2, 21.
Sartoretti P., Marchal O., Babusiaux C., et al. 2022, *A&A* accepted, arXiv:2206.05725
Tody D.: 1986, *Proceedings SPIE Instrumentation in Astronomy VI,* ed. D.L. Crawford, 627, 733.
Tody D.: 1993, *Astronomical Data Analysis Software and Systems II*, A.S.P. Conference Ser., eds. R.J. Hanisch, R.J.V. Brissenden, & J. Barnes, 52, 173.
van Dokkum P. G.: 2001, *PASP*, 113, 1420.