Short-term and long-term flux variability of extragalactic objects useful for the future Gaia CRF

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Journées 2019, Paris, France
7-9 October 2019

Introduction

- The FK5 (~1500 stars, +).

- HIgh Precision PARallax COllecting Satellite - Hipparcos Catalogue (ESA 1997) ~118000 stars, Nov 1989 – March 1993, J2000 equator, on the ICRS at epoch 1991.25 . Plus Tycho (~ 1 million stars) and Tycho-2 (~ 2.5 million stars). The XXIII General Assembly IAU (Kyoto, 1997). Hipparcos-2 (van Leeuwen 2007) – new reduction.

Gaia mission

- ESA mission – Gaia (end of 2013), in astrometry and photometry until V=20 mag or ~1 billon sources and to 16 mag in spectroscopy or ~150 million objects (Prusti 2012). Gaia celestial reference frame - Gaia CRF in the future (QSOs based one).

- At 2013 we established the “Serbian-Bulgarian mini-network telescopes”. Plus two SASA-BAN joint research projects: “Observations of ICRF radio-sources visible in optical domain” (2014-2016) and “Study of ICRF radio-sources and fast variable astronomical objects” (2017-2019). Photometry and morphology of QSOs useful for the link ICRF - Gaia CRF

Gaia Second Data Release - DR2

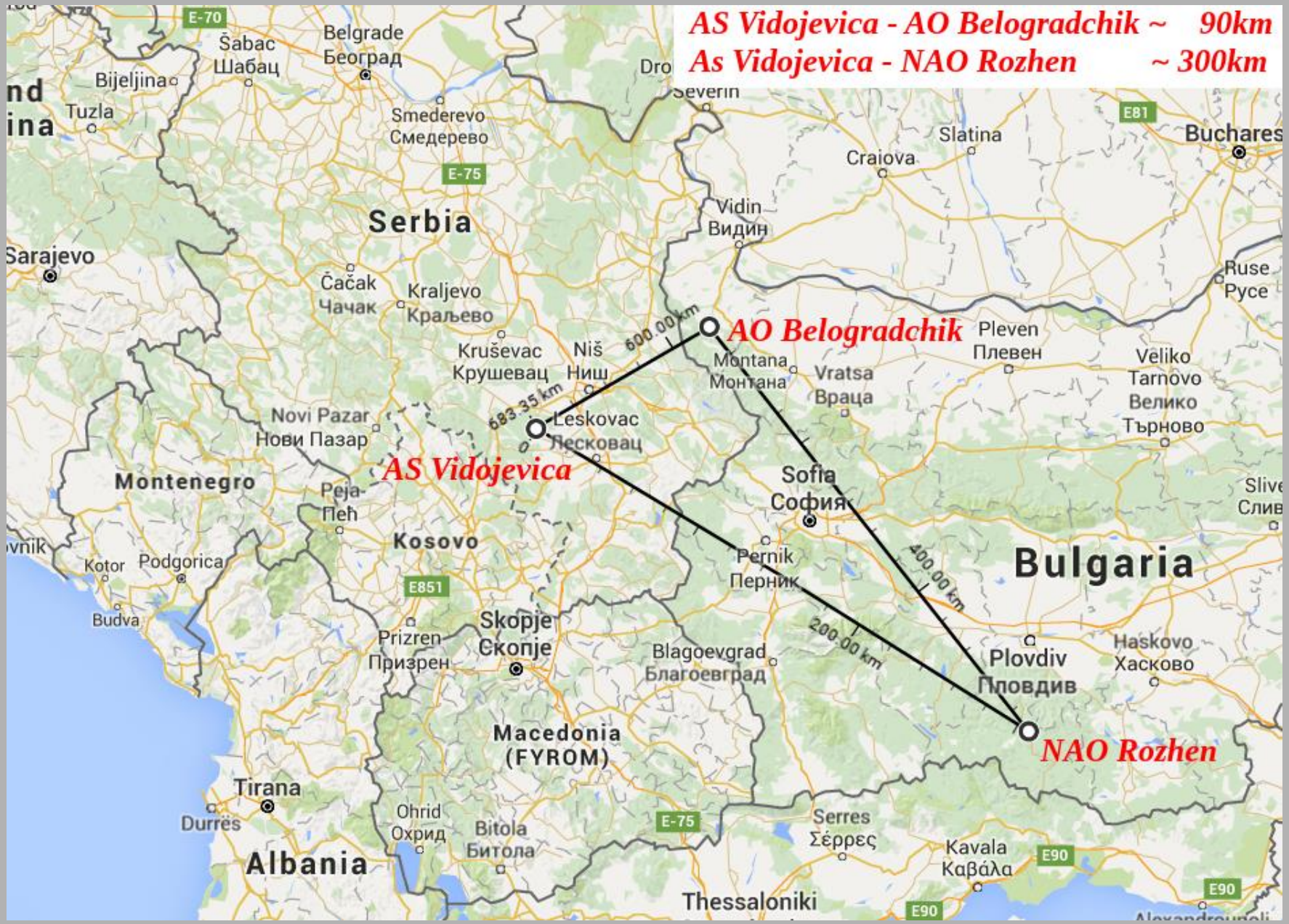
- The Global Astrometric Interferometer for Astrophysics - GAIA. Astrometrically, photometrically and spectroscopically surveying the full sky. Dec 2013, the ESA space astrometry mission or Gaia satellite. The Gaia DR1 (September 2016) and DR2 (April 2018).
- DR1: 14 months, ~ 2 million stars (Tycho-Gaia astrometric solution). DR2: 22 months, 1.3 billion stars at J2015.5 and 0.4 billion faint sources.
- two A&A papers: (Taris, Damljanovic, et al., 2018), (Damljanovic & Taris, 2019, in press).

Mini-network (3 sites, 6 telescopes):

- 60cm (mid-2011) and 1.4m tel.(mid-2016) of Astronomical Station Vidojevica - ASV of Astronomical Observ. in Belgrade - AOB (Serbia),
- 2m, 60cm and 50/70cm Schmidt-camera at Rozhen Obs., National Astronomical Observatory (NAO) of Bulgarian Academy of Sciences (BAS),
- 60cm Belogradchik AO (Bulgaria).

- Telescope Joan Oro – TJO, TAROT, LFOA data.
- Johnson UBV and Cousins RI filters.

ASV, Belogradchik and Rozhen



Instruments:

1) 60 cm Cassegrain (long.=21.5º, lat.=43.1º, h=1136m), CCD Apogee Alta U42, ASV (Serbia),
2) 1.4m (21.6, 43.1, 1143m), CCD Apogee Alta U42, ASV(Serbia),
3) 2m Ritchey-Chrétien (24.7º, 41.7º, 1730m),
CCD VersArray 1300B (April 2018), Rozhen Obs. (Bulgaria),
4) 60cm Cassegrain (24.7º, 41.7º, 1759m),
CCD FLI PL09000, Rozhen Obs. (Bulgaria),
5) 50/70cm Schmidt-camera (24.7º, 41.7º, 1759m),
CCD FLI PL16803, Rozhen Obs. (Bulgaria),
6) 60cm Cassegrain (22.7º, 43.6º, 650m),
CCD FLI PL09000, Belogradchik (Bulgaria).

CCD cameras

Schmidt-camera 50/70cm

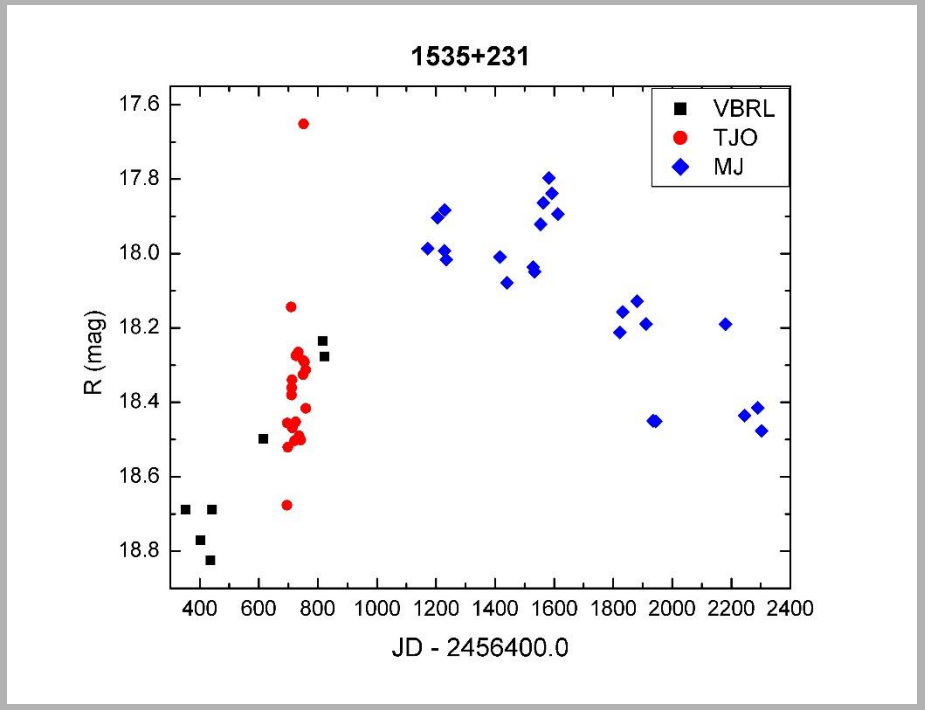
1) The ASV (D/F=0.6/6m) tel. The CCD Apogee Alta U42: 2048x2048 pixels, pixel size is 13.5x13.5 μm, scale is 0.″465/pixel, FoV=15.8x15.8′, + SBIG ST10 XME & Apogee Alta E47.

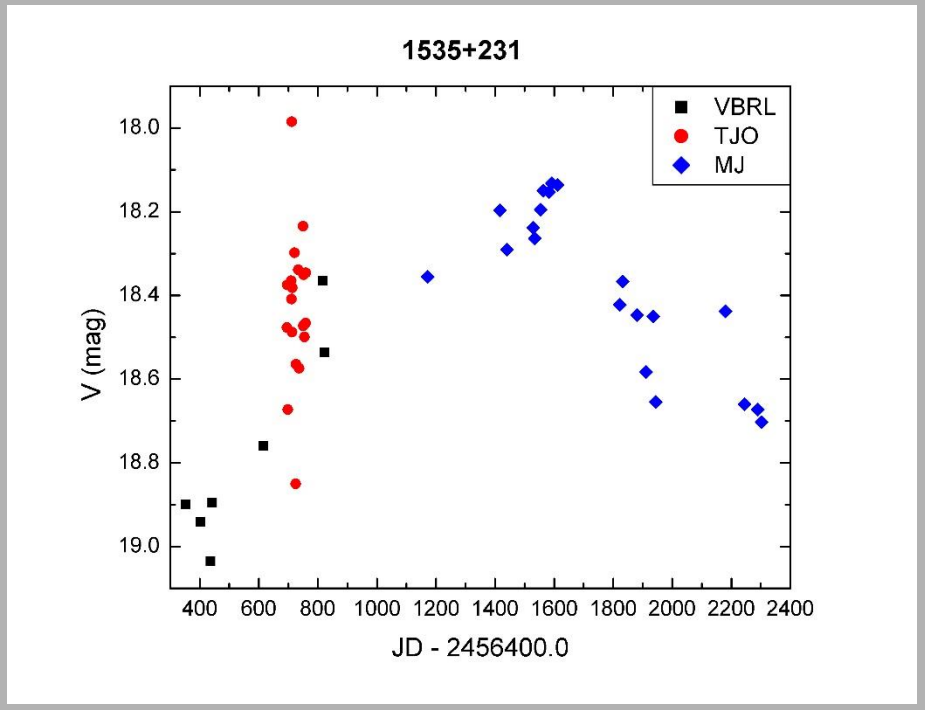
2) The R.C. (D/F=2/15.77m) tel. of Rozhen National Astronomical Observatory (NAO) of Bulgarian Academy of Sciences (BAS). CCD VersArray 1300B: 1340x1300, 20x20μm, 0.″261/px, 5.6x5.6′, + Andor iKon-L from April 2018 (2048x2048, 13.5x13.5μm,0.″176/px).

The 1.4m ASV (Ritchey-Chrétien, Nasmyth, BELISSIMA), dome-2018

The 2m Rozhen telescope with CCD Andor iKon-L

3) The 60cm Rozhen (F=7.5m) tel.
The CCD FLI PL09000: 3056x3056, 12x12µm, 0.″33/pixel, 16.8x16.8‘; under reconstruction from 2016 until mid-2018.
4) The 50/70cm Schmidt-camera (F=1.72m), Rozhen.
The CCD FLI PL16803: 4096x4096, 9x9µm, 1.″08/pixel, 73.7x73.7' .
5) The 60cm Belogradchik (F=7.5m) tel.
The CCD FLI PL09000: 3056x3056, 12x12µm, 0.″335/pixel, 16.8x16.8'.
6) The 1.4m ASV (F=11.42m) tel. since mid-2016. The CCD Apogee Alta U42: 2048x2048, 13.5x13.5 µm, 0.″243/pixel, 8.3x8.3’, CCD Andor iKon-L 936 (2048x2048 pixels, 13.5x13.5µm, 0.″244, 8.3x8.3’), new EMCCD Andor iXon 897 for lucky imaging.


1535+231
VBRL
TJO
MJ
R (mag)
JD - 2456400.0


1535+231
VBRL
TJO
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V (mag)
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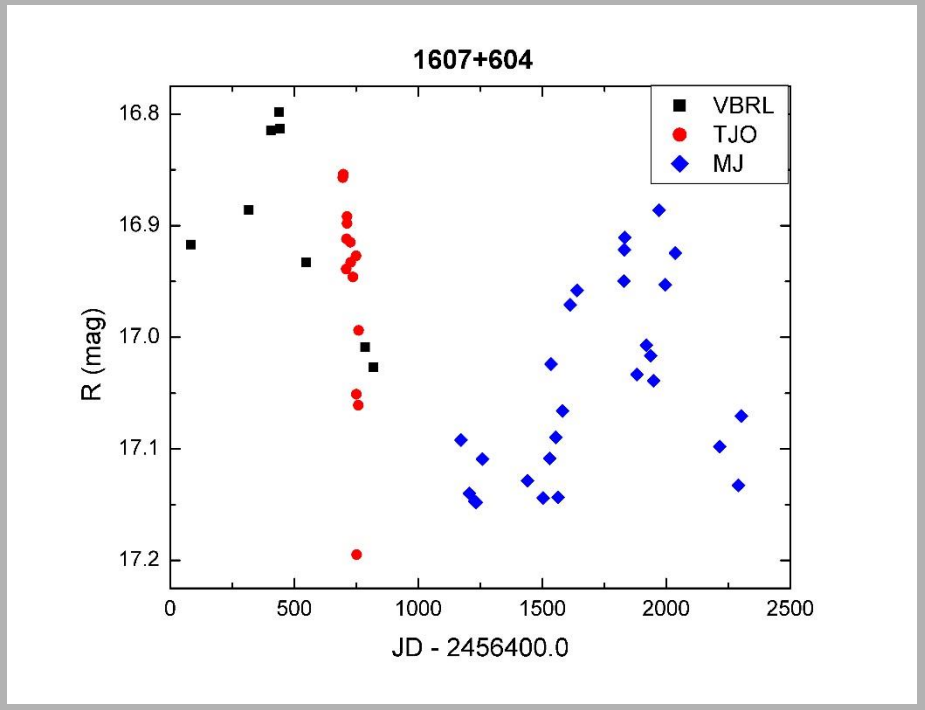
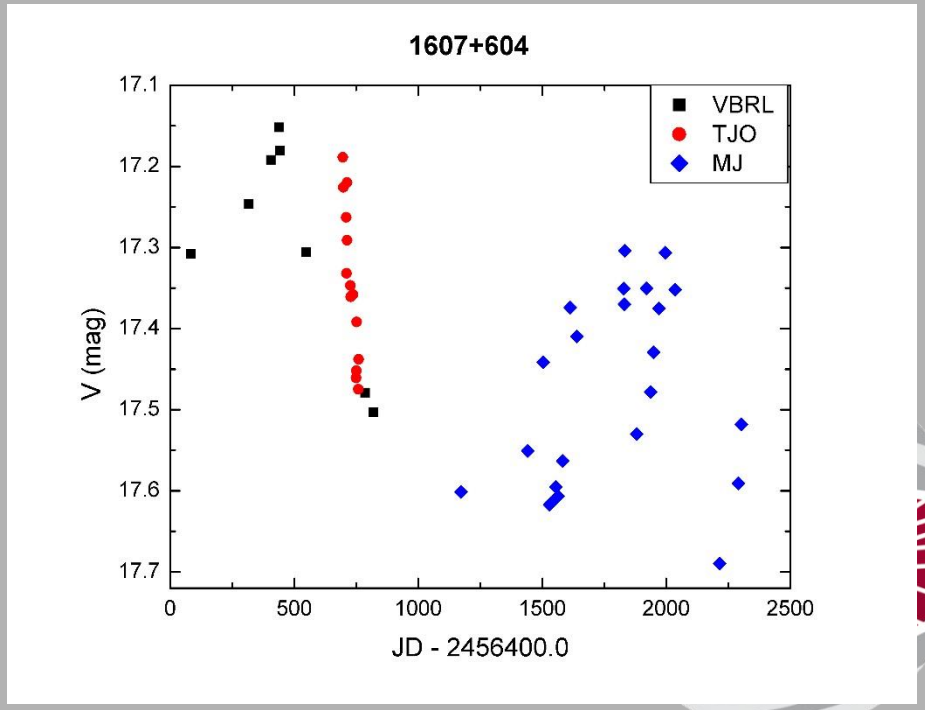
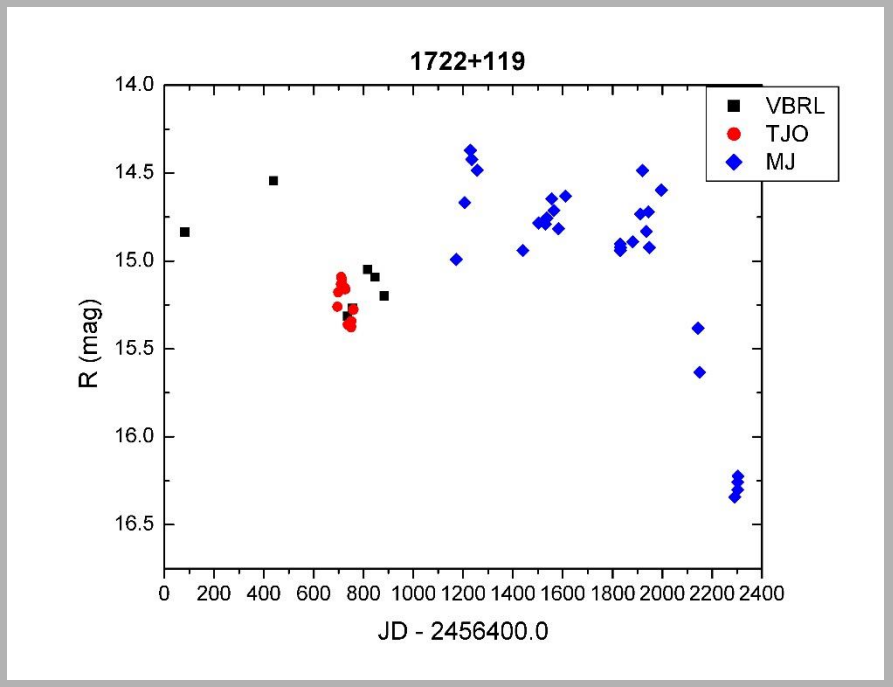
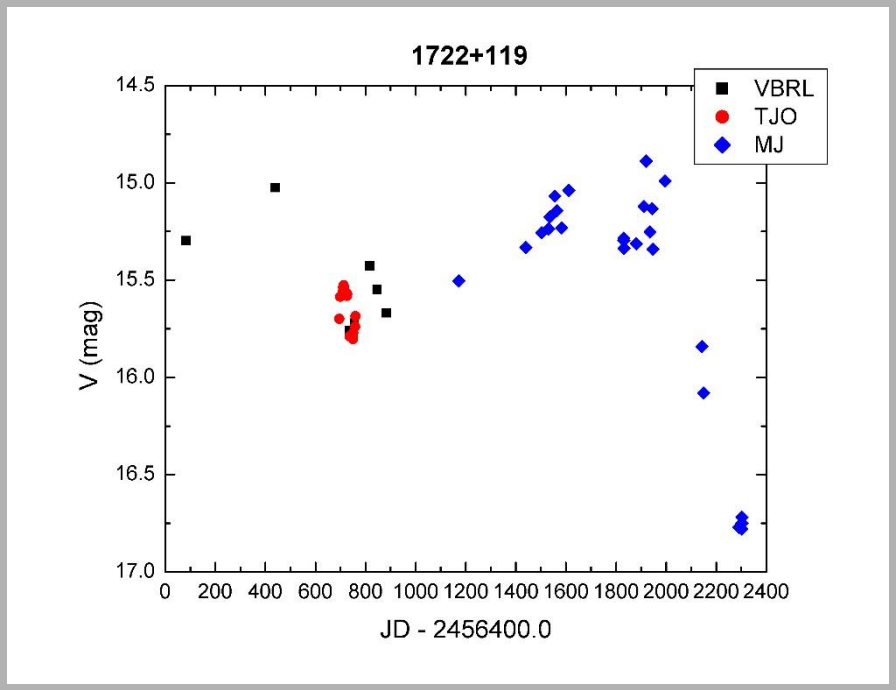
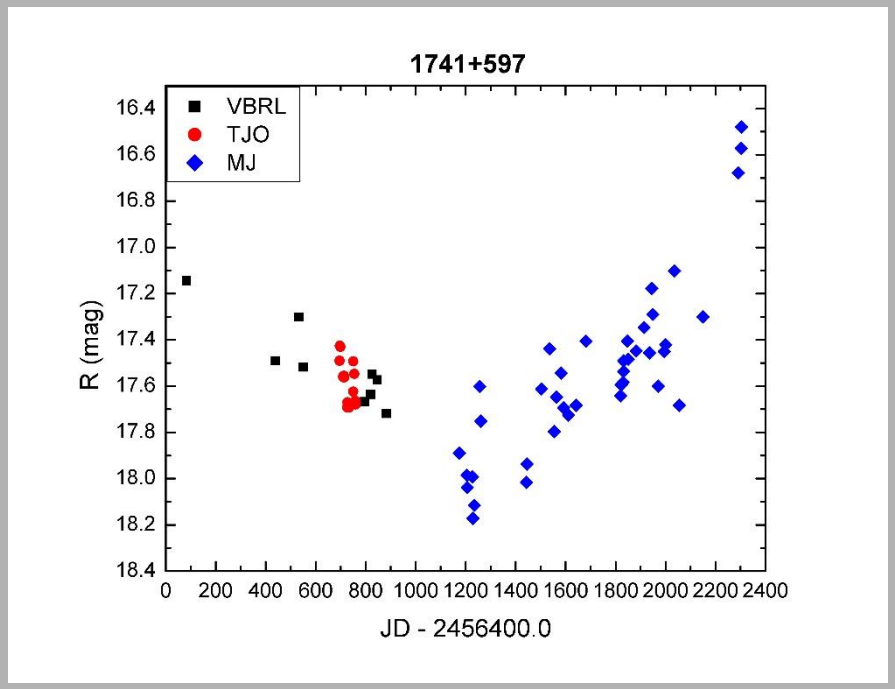
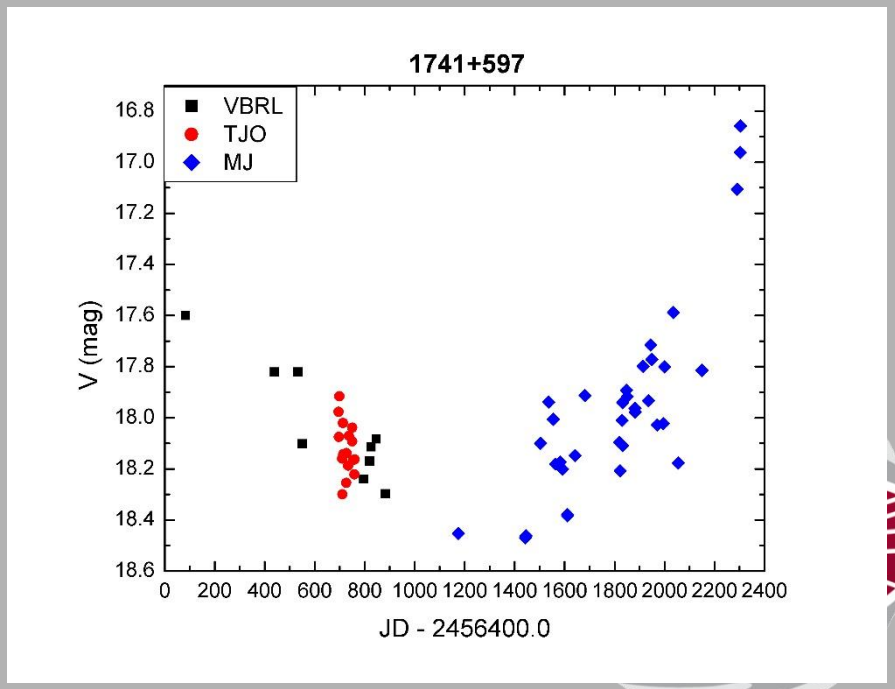

1607+604
VBRL
TJO
MJ
R (mag)
JD - 2456400.0

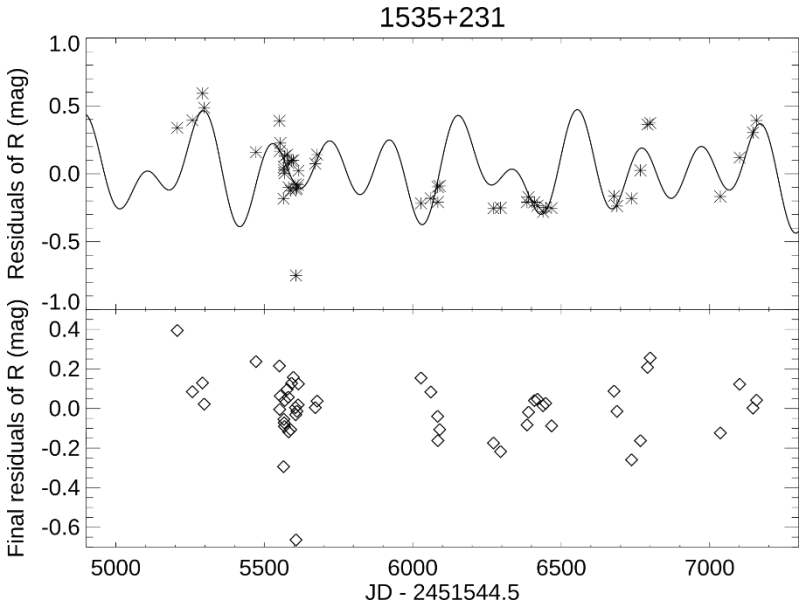

1607+604
VBRL
TJO
MJ
V (mag)
JD - 2456400.0

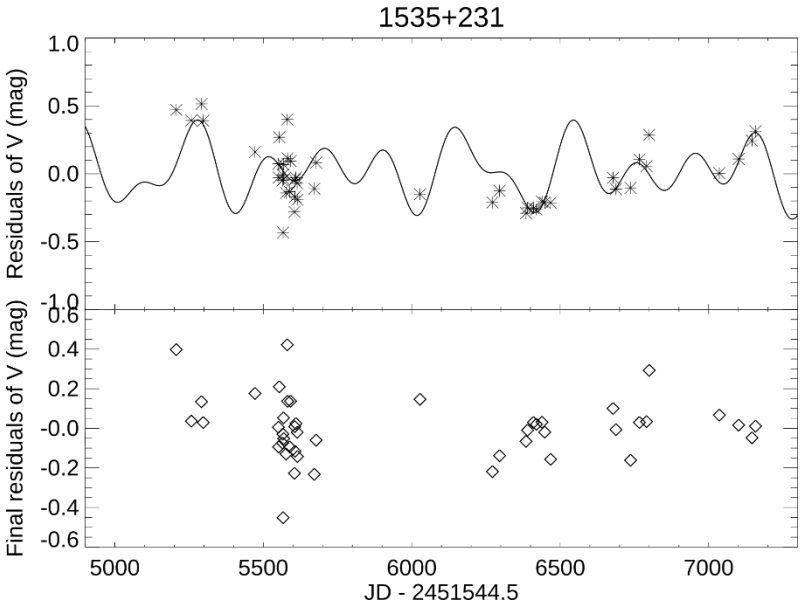

1722+119
VBRL
TJO
MJ
R (mag)
JD - 2456400.0

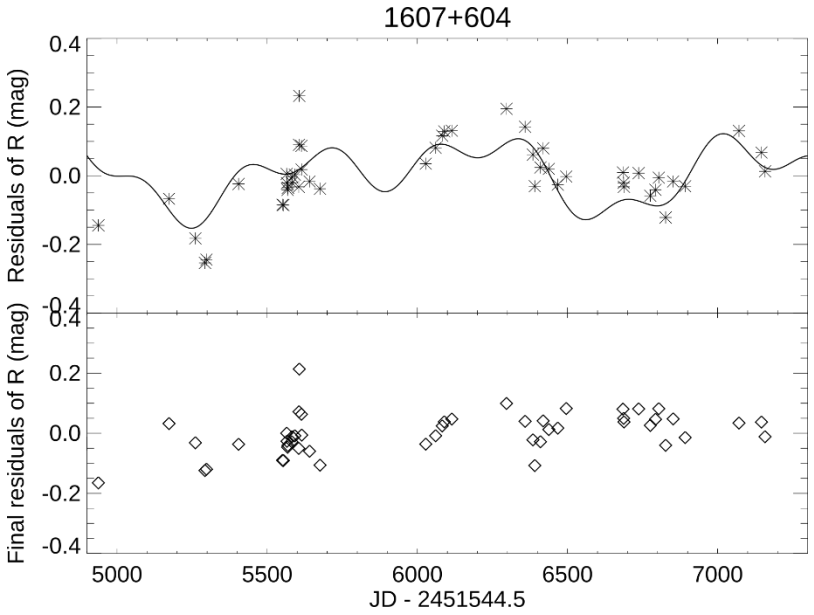

1722+119
VBRL
TJO
MJ
V (mag)
JD - 2456400.0

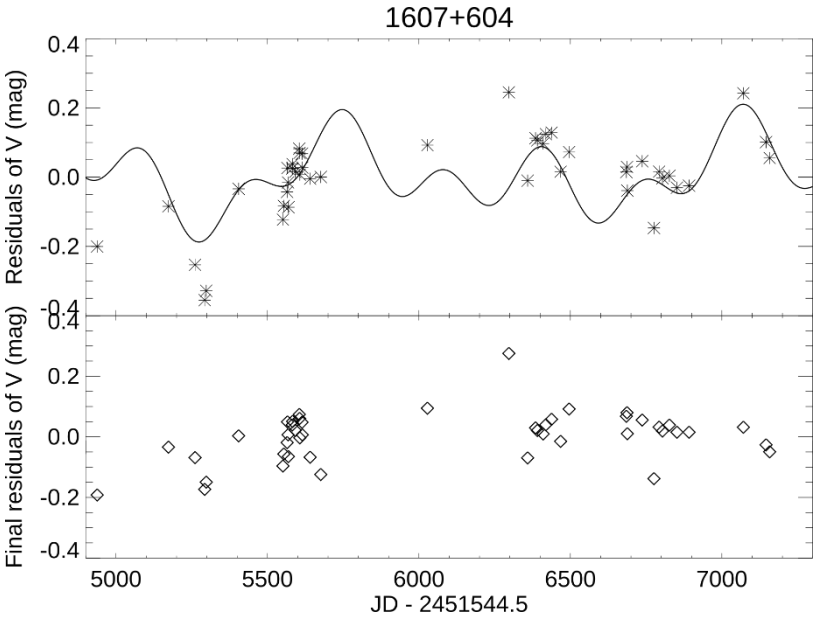

1741+597
VBRL
TJO
MJ
R (mag)
JD - 2456400.0

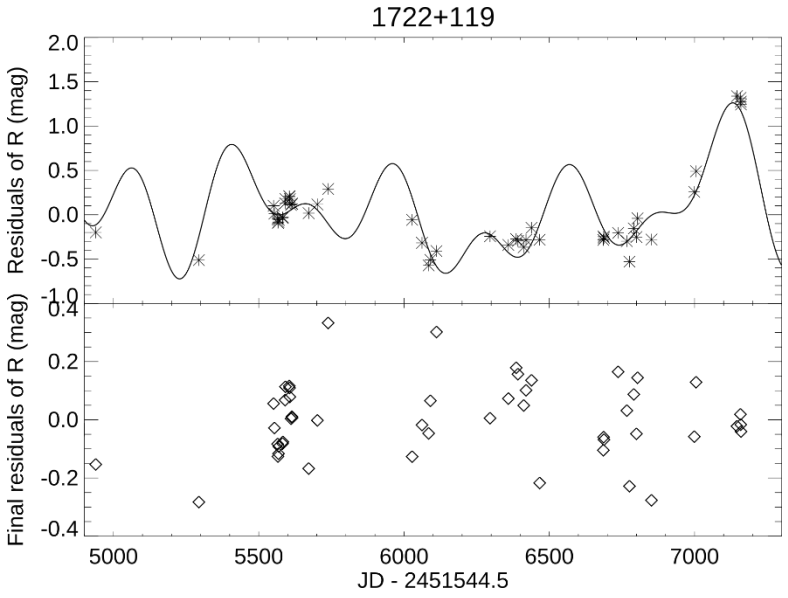

1741+597
VBRL
TJO
MJ
V (mag)
JD - 2456400.0

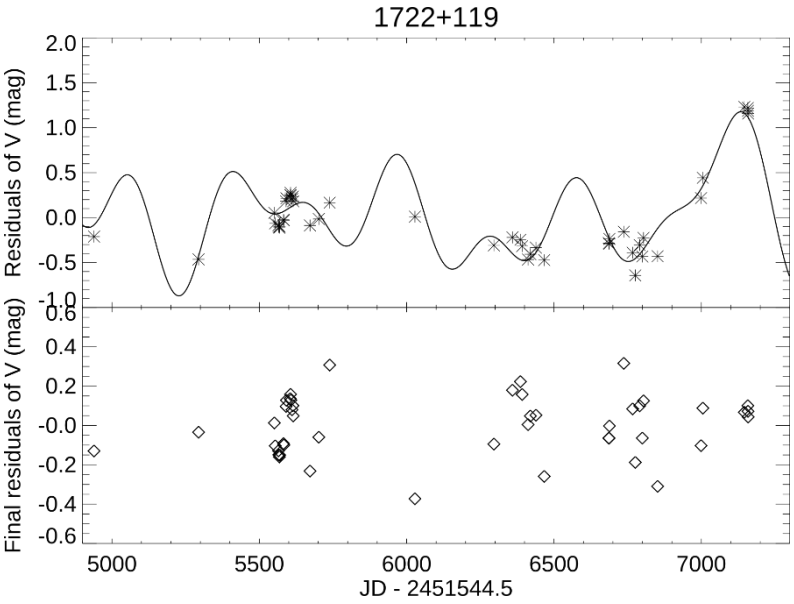

1535+231
Residuals of R (mag)
Final residuals of R (mag)
JD - 2451544.5

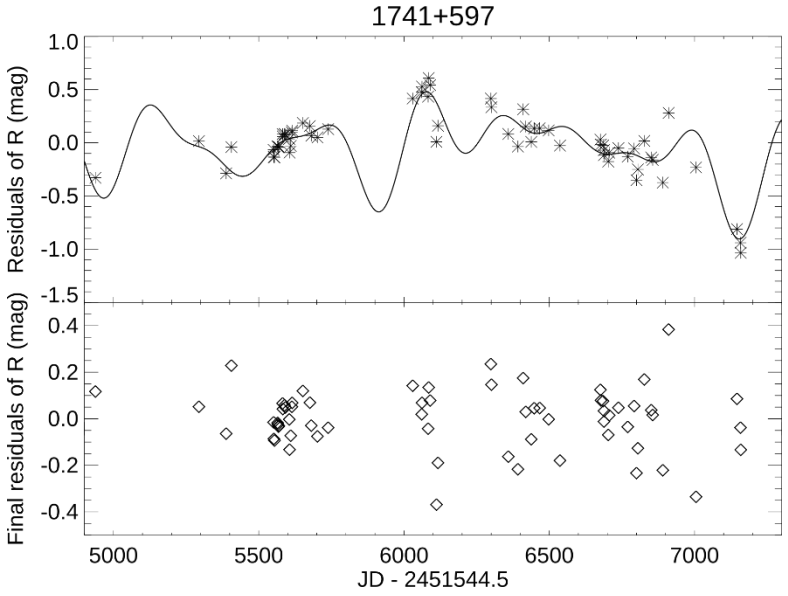

1535+231
Residuals of V (mag)
Final residuals of V (mag)
JD - 2451544.5


1607+604
Residuals of R (mag)
Final residuals of R (mag)
JD - 2451544.5


1607+604
Residuals of V (mag)
Final residuals of V (mag)
JD - 2451544.5


1722+119
Residuals of R (mag)
Final residuals of R (mag)
JD - 2451544.5


1722+119
Residuals of V (mag)
Final residuals of V (mag)
JD - 2451544.5


1741+597
Residuals of R (mag)
Final residuals of R (mag)
JD - 2451544.5

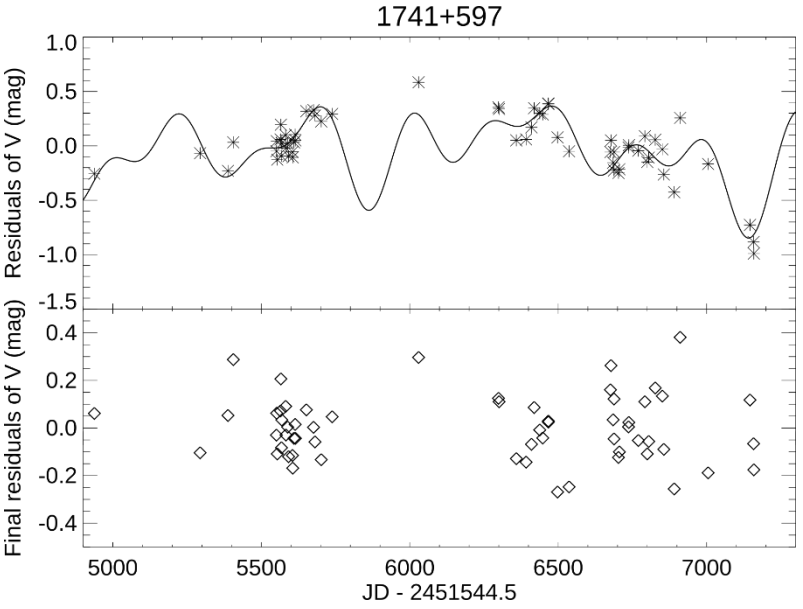

1741+597
Residuals of V (mag)
Final residuals of V (mag)
JD - 2451544.5

Table. The amplitudes of obtained quasiperiods for 1535+231, 1607+604, 1722+119, and 1741+597.

Object	Filter	Period (y)	$A \pm \sigma_A$ (mag)
1535+231	V	0.57, 0.88, 1.21	0.158 ± 0.028, 0.132 ± 0.025, 0.133 ± 0.022
	R	0.57, 0.87, 1.21	0.233 ± 0.028, 0.143 ± 0.024, 0.122 ± 0.022
1607+604	V	0.90, 1.86, 3.90	0.067 ± 0.016, 0.096 ± 0.013, 0.048 ± 0.012
	R	0.87, 1.99, 3.69	0.045 ± 0.012, 0.067 ± 0.010, 0.062 ± 0.009
1722+119	V	0.83, 0.88, 1.08,	0.392 ± 0.052, 0.126 ± 0.030, 0.122 ± 0.028,
		1.52, 1.77, 3.43, 4.43	0.461 ± 0.037, 0.169 ± 0.024, 0.217 ± 0.032, 0.150 ± 0.021
	R	0.82, 0.88, 1.10,	0.399 ± 0.049, 0.122 ± 0.024, 0.134 ± 0.017,
		1.52, 1.90, 3.55, 4.76	0.386 ± 0.039, 0.184 ± 0.034, 0.139 ± 0.020, 0.265 ± 0.026
1741+597	V	0.70, 0.90, 1.17,	0.178 ± 0.023, 0.119 ± 0.033, 0.205 ± 0.027,
		1.59, 3.07, 4.97	0.110 ± 0.018, 0.159 ± 0.020, 0.119 ± 0.017
	R	0.67, 0.85, 1.18,	0.131 ± 0.021, 0.177 ± 0.025, 0.214 ± 0.030,
		1.58, 3.49, 5.66	0.121 ± 0.017, 0.140 ± 0.019, 0.102 ± 0.015

Conclusions

- Six telescopes, and BVRI filters; the seeing=1.″0 to 3.″5 (mean ~1.″2 at ASV, it could be 0.″7 at Rozhen and ASV).
- Photometry and morphology investigation of QSOs useful for the link ICRF – Gaia CRF. A&A papers: (Taris, Damljanovic,et al. 2018),(Damljanovic&Taris 2019, in press).
- It is possible to observe the objects until V~20mag by using 2m Rozhen or 1.4m ASV (Exp.time. ~5min), or until V~19mag with smaller instruments.
- The 1.4m tel. at ASV site from mid-2016, Belissima. CCD Andor iKon-L 936 on 1.4m ASV and 2m Rozhen, new EMCCD Andor iXon 897 for lucky imaging.
- Quasiperiods (four QSOs), 1556+335 is stable (F-test).

Thank you!