Astronomy and Astrophysics in the Gaia sky
Proceedings IAU Symposium No. 330, 2017
A. Recio-Blanco, P. de Laverny, A.G.A. Brown & T. Prusti, eds.

doi:10.1017/S1743921317005282

Remarks of Gaia DR1 magnitude using ground-based optical monitoring of QSOs

Goran Damljanović[1], François Taris[2] and Alexandre Andrei[3]

[1]Astronomical Observatory, Volgina 7, 11060 Belgrade, Serbia
email: gdamljanovic@aob.rs

[2]Observatoire de Paris - SYRTE, CNRS/UPMC, 61 av. de l'Observatoire, 75014 Paris, France
email: Francois.Taris@obspm.fr

[3]Observatório Nacional/MCTI, Rua Gal. José Cristino 77, Rio de Janeiro, RJ CEP 20921-400, Brasil
email: oat1@ov.ufrj.br

Abstract. Since September 2016, the first release (DR1) of the Gaia catalogue was appeared. The optical Gaia positions of sources will be linked to the ICRF (VLBI radio positions of mostly quasars, QSOs). For high accurate link we need to investigate variations of optical flux of QSOs via their magnitude variations using data of ground-based telescopes. To do that, from 2013 we observed 47 QSOs and other sources; nine optical telescopes were used for that monitoring. To increase the total number of objects for the link, after a first set of 70 objects (Bourda *et al.* 2008), Bourda *et al.* (2011) established a second set of 47 objects. It is necessary to investigate the photometry and morphology of these objects. We collected ground-based data of QSOs (B, V and R mag) and compared with G mag of Gaia DR1; some results are presented here.

Keywords. Astrometry, reference systems, quasars: general.

1. Instruments and results

The installation of the 60 cm telescope at new site Astronomical Station Vidojevica - ASV (of Astronomical Observatory in Belgrade - AOB, Serbia) was in 2010, and of new 1.4 m ASV was in mid-2016. During 2013 we established the Serbian-Bulgarian mini-network of 6 telescopes. Also, we did with the 1.5 m telescope at the Leopold-Figl Observatorium für Astrophysics LFOA (Vienna Observatory, Universität Wien) after its reconstruction. And, we used the two TAROT telescopes (Taris *et al.* 2013, 2016) and robotic 0.8m Telescope Joan Oró - TJO (Observatori Astronòmic del Montsec, Spain).

The main information of the Serbian-Bulgarian telescopes and LFOA are:

1. ASV (AOB) Cassegrain $D/F(cm) = 60/600$ (longitude is 21.5 deg E, latitude is 43.1 deg N, altitude is 1140 m), CCD camera Apogee Alta U42, 2048x2048 pixels, 13.5x13.5 mkm pixel size, scale is 0.46 arcses, field of view (FoV) is 15.8x15.8 arcmin,

2. ASV (AOB) Ritchey-Chrétien 140/1142 (21.5 E, 43.1 N, 1150 m), Apogee Alta U42, 2048x2048 pixels, 13.5x13.5 mkm, scale is 0.24 arcsec, FoV is 8.3x8.3 arcmin,

3. Rozhen (NAO BAS) Ritchey-Chrétien 200/1577 (24.7 E, 41.7 N, 1730 m), VersArray 1300B, 1340x1300 pixels, 20x20 mkm, scale is 0.26 arcsec, FoV is 5.6x5.6 arcmin,

4. Rozhen (NAO BAS) Cassegrain 60/740 (24.7 E, 41.7 N, 1760 m), FLI PL09000, 3056x3056 pixels, 12x12 mkm, scale is 0.33 arcsec, FoV is 16.8x16.8 arcmin,

5. Belogradchik AO Cassegrain 60/740 (22.7 E, 43.6 N, 650 m), FLI PL09000, 3056x3056 pixels, 12x12 mkm, scale is 0.33 arcsec, FoV is 16.8x16.8 arcmin,

6. LFOA R.C. $D(cm) = 152$ (48.1 E, 15.9 N, 880m), SBIG ST-10 XME, 2184x1472 pixels, 6.8x6.8 mkm, scale is 0.15 arcsec, FoV is 3.8x5.6 arcmin.

The NAO BAS means National Astronomical Observatory of Bulgarian Academy of Sciences. Also, the 60 cm ASV was used with the CCD SBIG ST-10 XME: scale = $0.''23$, FoV is 8.4x5.6 arcmin. About TJO, see www.oadm.cat/en/home.htm. We collected about 7000 images. The Johnson-Cousins filters were available. The TAROT image reduction was described in papers by Taris *et al.* (2013, 2016). The standard bias, dark and flat-fielded corrections were done (also, hot/dead pixels were removed); this step was achieved using the PRISM commercial software (see www.prism-america.com). The next step, astrometric and photometric reduction, was done by the Gaia-GBOT Astrometric Reduction Pipeline (Bouquillon *et al.* 2014). The TJO magnitudes are relative ones, and they are calculated via a least square adjustment of the instrumental magnitudes of all known objects in the FoV. With other six telescopes, we observed targets in B,V and R bands (usually 3 CCD images per filter), and got the photometric results via comparison stars. The comparison stars were taken from the SDSS (or APASS) catalogue using suitable transformation (Chonis and Gaskell 2008). The calculated magnitude (B,V,R) is the average value (of 3 CCD images per filter) with st.error. Some our photometric results of 0049+003 are (using the 60 cm ASV telescope):

- Sep. 6^{th} 2013, $JD = 2456542.48866$ for $B = 16.669 \pm 0.027$ mag, $JD = 2456542.47938$ for $V = 16.296 \pm 0.021$ mag, $JD = 2456542.49410$ for $R = 15.877 \pm 0.014$ mag,
- Sep. 7^{th} 2013, $JD = 2456543.58255$, $B = 16.383 \pm 0.030$ mag, $JD = 2456543.57874$, $V = 16.280 \pm 0.030$ mag, $JD = 2456543.58638$, $R = 15.855 \pm 0.020$ mag.

The polynomial expression was used to get the G mag (from ground-based V and R ones), and to compare with G mag of the Gaia DR1: $G - V = -0.0120 - 0.3502(V - R) - 0.6105(V - R)^2$.

2. Conclusion

In the Gaia DR1 there is not epoch for each Gaia G-mag of QSOs (there is only the average G value) to compare with our ground-based results. The flux of QSOs is not constant with time. It is not clear what value of the Aperture Radius was used for the Gaia photometry reduction (which is very important for some QSOs as extended sources), etc. We hope, these values will be included into the next Gaia realize dataset.

Acknowledgements. This work has made use of data from the European Space Agency (ESA) mission *Gaia* (https://www.cosmos.esa.int/gaia), processed by the *Gaia* Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the *Gaia* Multilateral Agreement. GD acknowledges observing grant of Institute of Astronomy and Rozhen NAO BAS. This work is part of the Project No 176011 (Dynamics and kinematics of celestial bodies and systems), supported by Ministry of Education, Science and Technological Development of R. Serbia.

References

Bourda, G. *et al.* 2008, *Astronomy and Astrophysics*, 490, 403
Bourda, G. *et al.* 2011, *Astronomy and Astrophysics*, 526, A102
Bouquillon, S. *et al.* 2014, *SPIE*, 9152
Chonis, T. & Gaskell, C. 2008, *Astronomical Journal*, 135, 264
Taris, F. *et al.* 2013, *Astronomy and Astrophysics*, 552, A98
Taris, F. *et al.* 2016, *Astronomy and Astrophysics*, 587, A112