NEA characteristics based on the results of astrometric and photometric observations with the SBG telescope at the Kourovka Astronomical Observatory

Ural Federal University
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Planetary Defense Conference
PROTECTING EARTH FROM ASTEROIDS

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SBG telescope

Regular astrometric and photometric observations of NEAs are conducted using a SBG telescope (see Fig. 1) of the Kourovka Astronomical Observatory of the Ural Federal University (AO UrFU).

Figure 1. *The SBG telescope of the Kourovka Astronomical Observatory of the Ural Federal University*

The SBG telescope facilities are:

- The four-axis telescope with a **0.8 m focal length** is equipped with a **Schmidt optical system** and a **0.4 m diameter main mirror**.
- An **Apogee Alta U32 CCD camera** with a KAF-3200ME-1 CCD matrix containing 2184 × 1472 elements, each of size 6.8 × 6.8 μm is mounted at the main telescope focus.
- The scale of the CCD image is **1.8 arcsec/pixel**.
- The field of view of the system is **65 × 44 arcmin**.
- Limiting magnitude is **19 mag**.
- Observations with filters of the wideband **UBVRI** system are available.

The precision timing system uses a 12-channel GPS receiver Acutime 2000 GPS Smart Antenna.

The accuracy of observations

Astrometric and photometric observations of asteroids have been made with **the filter R**.

- The accuracy of astrometric observations is analyzed in papers (Kaiser & Wiebe 2017) and (Kuznetsov et al. 2017).
- **The astrometry root-mean-square (RMS) residuals (O-C)** for equatorial coordinates consist of **0.01-0.3 arcsec** for bright objects when the magnitude is **less than 18.5 mag**, and **0.5-0.7 arcsec** for faint objects with magnitude **from 18.5 to 19 mag**.
- The RMS residuals (O-C) for equatorial coordinates is increased for the near Earth objects (NEO) and potentially hazardous asteroids (PHA).
- In case of the angular velocity of NEO is **less than 0.5 arcsec/min**, the astrometry RMS residuals (O-C) comprised of **0.1-0.5 arcsec** for bright NEO when the magnitude is **less than 16.5 mag**, and **0.9-1.0 arcsec** for faint objects with magnitude from **16.5 to 18 mag**.
- The astrometry RMS residuals (O-C) consist of **0.5-0.6 arcsec** for **NEO** with magnitude **from 9.5 to 11.5 mag** and angular velocity **from 20 to 40 arcsec/min**.

- **Photometry RMS errors** consist of **0.05 mag** for bright objects when the magnitude is **less than 16.5 mag**, and **0.07-0.15 mag** for faint objects with the magnitudes **from 16.5 to 18 mag**.

Software

- The SBG telescope and the CCD system are operated by the **SBGControl** software (Glamazda 2012) developed at AO UrFU.
- Astrometric processing of the observations has been made using **IzmCCD** (Izmailov et al. 2010) and AM:PM (Krushinsky2017) Software Packages.
- We used the **IDA** Software Package (Bykova et al. 2012) to improve the orbital elements of the asteroids.
- The code known as **Orbit9** (**OrbFit** Software Package (OrbFit Consortium 2011)) has been used to research the dynamical evolution of asteroids.

Table 1. *Periods P and color indices V-R of the NEA*

NEA	P [hour]	P [hour] (http://alcdef.org/)	V–R [mag]	V–R [mag] (http://alcdef.org/)
(2061) Anza	11.62 ± 0.31	6.7121 ± 0.0041 or 11.4607 ± 0.0005	—	—
(2102) Tantalus	2.5 ± 1.2	2.3839 ± 0.0010	0.46 ± 0.10	—
(3200) Phaethon	3.6250 ± 0.0007	3.5971 ± 0.0019	0.35 ± 0.14	0.33 ± 0.01
(52768) 1998 OR2	4.11 ± 0.11	4.1100 ± 0.0036	0.38 ± 0.06	—
(65690) 1991 DG	7.10 ± 0.98	7.1112 ± 0.0007	0.35 ± 0.14	0.40 ± 0.01
(68216) 2001 CV26	2.235 ± 0.088	2.4290	—	—
(152931) 2000 EA107	4.03 ± 0.29	4.1366 ± 0.0002	—	—
(153201) 2000 WO107	5.64 ± 0.14	5.64 ± 0.14	—	—
(155140) 2005 UD	—	—	0.38 ± 0.05	0.35 ± 0.02
(163373) 2002 PZ39	—	—	0.43 ± 0.14	—
(388945) 2008 TZ3	—	—	0.41 ± 0.10	0.39 ± 0.02
(523788) 2015 FP118	3.07 ± 0.72	3.0917 ± 0.0007	—	—

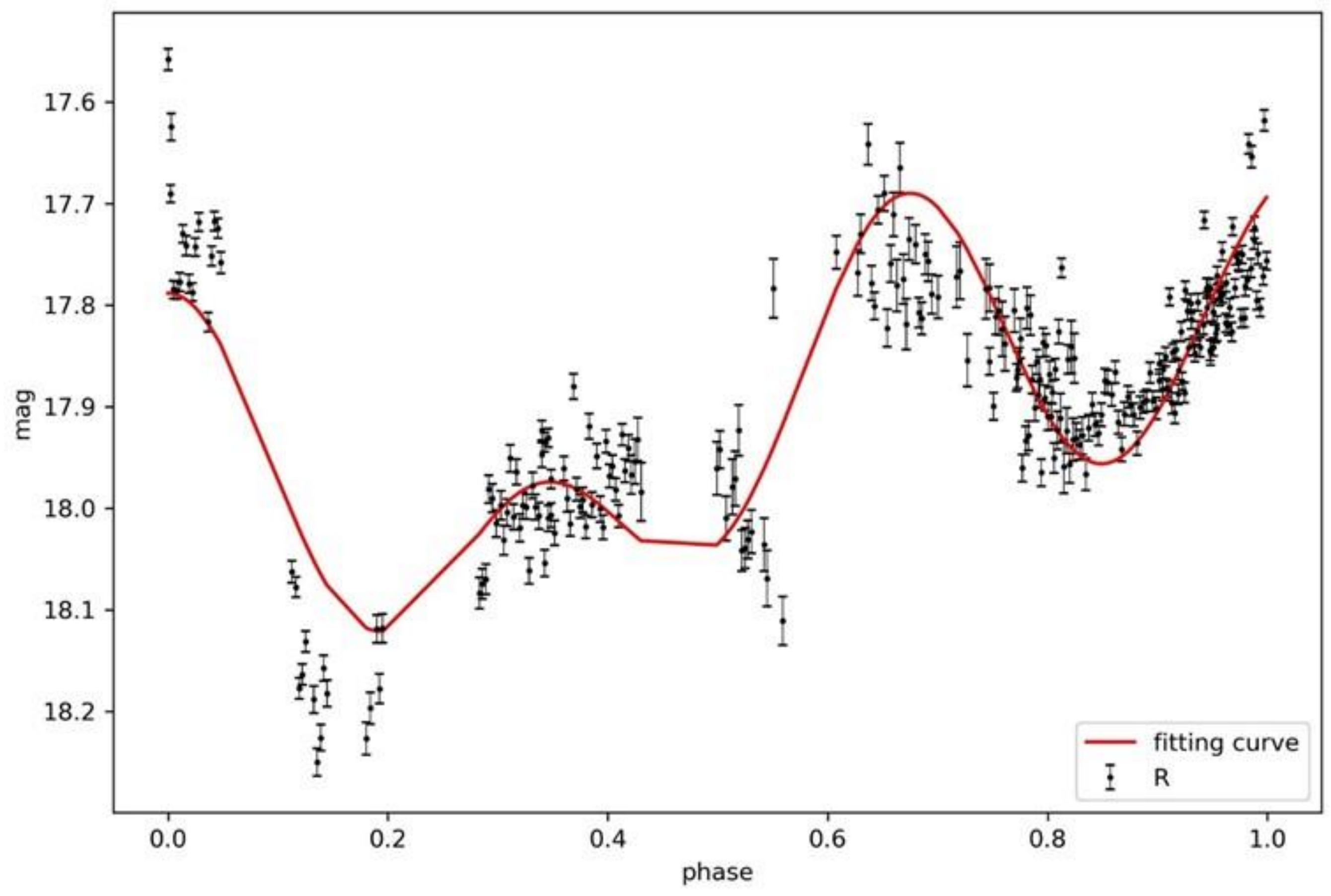

Figure 2. *Phase light curve of the NEA (2061) Anza (six nights, R filter)*

Results

- From 2007 to 2020 we have observed **338 near-Earth asteroids** with magnitudes **from 9.5 to 19 mag**:
- **157 Apollo** asteroids including 74 PHA,
- **144 Amor** asteroids with 13 PHA,
- **35 Aton** asteroids including 12 PHA,
- **two Atira** asteroids – (163693) Atira and (367943) Duende.

- We have got **improved** elements of the NEA's **orbits** and evaluated the axial **rotation periods** and **color indices**.
- **Table 1** gives estimates of the periods of axial rotation and color indices obtained from the photometric observations. The values from the ALCDEF (http://alcdef.org/) are also given.
- As an example, **Figure 2** shows the phase light curve of the NEA (2061) Anza (six nights, R filter).

Discussion and Conclusions

- **Intense positional and photometrical observations** of NEAs are needed to improve the accuracy of NEAs ephemeris. It is necessary to take into account the influence of **the Yarkovsky effect**.
- In the future, we plan to refine the values of the **A2 parameter** and the **semimajor axis drift rates** due to the Yarkovsky effect based on astrometric observations.
- Determining the **position of the NEA's axis of rotation** based on photometric observations will make it possible to correctly take into account the influence of the Yarkovsky effect.

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