PHOTOMETRY OF THE TRANS-NEPTUNIAN OBJECTS (47171) TC_{36}, (50000) QUAOAR AND (84922) VS_2

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Abstract

Broadband CCD photometry of three Trans-Neptunian Objects (47171) 1999 TC36, (50000) Quaoar and (84922) 2003 VS2 were carried out in 2004 with 2m RCC telescope of the Bulgarian National Observatory – Rozhen. For the first object the period of rotation, lightcurve and amplitude were determined. For the second object we derived its rotational period and amplitude. The period of 50000 Quaoar was derived on the base of a partial lightcurve coverage. Observations of (20000) Varuna were made also for studying its oppositional effect. The results are described in the poster by Belskaya et al. presented at this symposium. The results of our observations are discussed and a comparison is made with the available data for these objects.

1. Instrumentation

The study of Kuiper belt population is of great interest since they have undergone only slight changes from the time of their formation in the solar nebula. The study of their nature and interrelations with classical small bodies is very important for a complete understanding of the mechanisms of the Solar System formation and evolution. A coordinated programme of photometric and polarimetric observations of distant small bodies was started between Bulgaria and Ukraine, respectively Institute of Astronomy with National Astronomical Observatory – Rozhen, Bulgarian Academy of Sciences and Institute of Astronomy, Kharkiv University. The goal of this informal collaboration is to enlarge observational data on physical properties of objects from different dynamical groups of small Solar system bodies, namely distant asteroids, short-periodic comets, Cenraurs and Kuiper Belt objects and to support the progress in theoretical modeling of the Solar system formation and evolution. We would like to mention that this scientific cooperation is without any additional funding, but we think the beginning is encouraging. The first results are presented at this symposium in two posters, this one and one by Belskaya et al.

2. Observations and data reduction

The observations were made with the Carl Zeiss Jena 2m Ritchey-Chretien-Coude (RCC) telescope of the Bulgarian National Astronomical Observatory – Rozhen (λ=1h38m52s, φ=+41°43" and latitude of 1750m). A Photometrics CE200A-SITe, backside illuminated CCD camera was used. The size of the chip is 1024x1024px and 1px=24μm. The field of view was 5'x5' with a resolution of 0.726"/pix in binning and 0.363"/px in the normal mode. The observations were made in the standard Johnson-Cron-Cousins R filter. The images were bias-subtracted, for this purpose master biases were used (Howell, 2000). Then the images were flat-fielded by using the median of a set of five images, taken at the twilight sky.

For the photometric reduction an aperture photometry was carried out using CCDPHOT software (Buie, 1998). For all objects the aperture was 8 px. It gives a lowest scatter of the data. The background was subtracted after it was measured in a ring around the object with radius from 20 to 50 px.

In Table 1 the aspect data during observations are presented. It includes date of observations and UT at the beginning of observations, apparent visual magnitude V, duration of observations, heliocentric (r) and geocentric (Δ) distances and solar phase angle (α).

Table 1. Date and observing circumstances

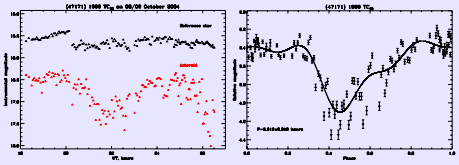
Object	Date, UT start	*Apparent mag (V)*	*Duration (hours)*	*r*, [AU]	*Δ*, [AU]	*α* [°]
47171 (1999 TC_{36})	8 Oct 2004 18:15	19.67	7.72	31.0747	30.0980	0.39
50000 Quaoar	11 June 2004 21:05	19.09	3.47	43.3715	42.3754	0.26
84922 (2003 VS_2)	9 Nov 2004 17:58	19.55	4.422	36.4302	35.4808	0.45

2.1. Object (47171) 1999 TC_{36}

The trans-Neptunian object (47171) 1999 TC36 belongs to the dynamical class Plutinos. Its diameter is about 609 km (Altenhof et al. 2004). This TNO has been found to be a binary (Trujillo&Braun 2001) with a magnitude difference between components of about 2 mag. The estimated ratio of the primary component radius to that of the secondary component is 2.7±0.1 with the orbital period of 7640±460 hours (Margot et al. 2004). Previous lightcurve observations (Peixinho et al. 2002; Ortiz et al. 2003a) revealed a small amplitude less than 0.1 mag. In one of the observing run (September 2001) a periodic signal was detected with a period of 6.21±0.02 hours (Ortiz et al. 2003a) while previous observations in September 2000 (Peixinho et al. 2002) and in August 2001 (Ortiz et al. 2003a) did not reveal any periodicity.

We observed this object on October 8, 2004. During the observations a binning 2x2 was used and resolution was 0.726"/px. At the beginning of the observation the seeing was 3"-4" and an exposure time of 180 sec was used. During the night the seeing was improved. Near the end of the night the seeing has improved to 2" and the exposure time was decreased to 120 seconds. Object drift rate during the integration was less than 0.2 arcsec. Fig. 1 shows the observed lightcurve of 1999 TC36 on October 8, 2004 and measurements of two reference stars. The shift of the magnitude at near 20 hours in UT clearly seen for the stars is connected with the change of exposure time. Both reference stars show the same magnitude behaviour with a random scatter which characterized an accuracy of our observations. In the same time the changes in object's magnitude are considerably larger and exceed 0.7 mag. Taking into account that previous observations revealed very low lightcurve amplitude the large amplitude detected by us can be probably explained as caused by mutual occultations/eclipses events of the binary body. The obtained lightcurve resembles long-period lightcurves of binary asteroids with a deep primary minimum and a flat secondary one (e.g. Pravec et al. 2000). Further observations of 1999 TC36 are needed to confirm its complex rotation.

Fig 1. Observations and lightcurve of (47171) TC36 and references stars obtained on October 8, 2004

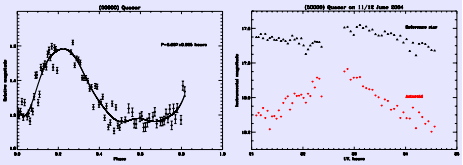


2.2. Object 50000 Quaoar

The trans-Neprunian object 50000 Quaoar belongs to the classical disk population. It is one of the largest TNOs with estimated diameter of 1260 km from disk-resolved images taken at HST with albedo of 0.1 (Brown & Trujillo, 2004). Its lightcurve observations were carried out in 2003 by Ortiz et al. (2003b) and revealed a double-picked period of 17.6788 hours with lightcurve amplitude of 0.13±0.03 mag. The object drift rate was less than 0.2 arcsec during the integration.

An amplitude of the observed part of Quaoar's lightcurve is about 0.2 mag (Fig. 2) which is consistent with previous observations (Ortiz et al. 2003b) within their observational scatter. However our observations seem to contradict to a long rotation period. For the rotation period of 17.68 hours the observed part of lightcurve covered only 20% of rotation cycle. Since both the lightcurve maximum were observed judging from the obtained amplitude it means that our observations covered a lot more than 20% of rotation cycle and thus, the rotation period of Quaoar seems to be shorter.

Fig 2. Observations and lightcurve of 50000 Quaoar and references stars obtained on June 11, 2004

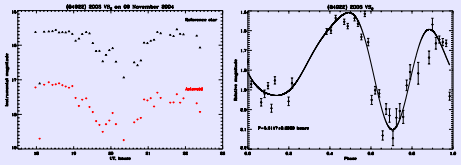


2.3. Object (84922) 2003 VS_2

The observations of TNO 84922 were made during 4.4 hours on November 2004. The resolution was 0.363". The seeing during the observation was ranged from 1.4 arcsec to 2.5 arcsec. The exposure time was 300 sec and the drift rate during the integration was 0.32 arcsec. Unfortunately, our observations did not reveal any confidence lightcurve features (see Fig. 3).

The derived amplitude is 0.593+-0.064m. These are the first data for period determination of this object. The lightcurve is double picked with one maximum higher than other and minima deeper than the other. The differences between them are 0.085mag. and 0.174mag respectively. The period derived by us is of 5.3117-+0.2000h.

Fig 3. Observations and lightcurve of (84922) VS32 and reference star obtained on November 9, 2004



3. Conclusion

We present the first lightcurve observations of three trans-Neptunian objects made with 2m telescope of the Bulgarian National Astronomical Observatory – Rozhen. These test observations have shown some interesting features, in particular a possible detection of occultation/eclipse events in the lightcurve of binary TNO (47171) 1999 TC36.

Based on our first experience we plan to improve the observing method and to continue systematic observations of TNOs lightcurves.

References

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