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DISCOVERY, OBSERVATIONAL DATA AND THE ORBIT OF THE TRANSNEPTUNIAN OBJECT (420356) PRAAMŽIUS

K. Černis[1], R. P. Boyle[2] and I. Wlodarczyk[3]

[1] *Institute of Theoretical Physics and Astronomy, Vilnius University, Saulėtekio al. 3, Vilnius LT-10222, Lithuania; Kazimieras.Cernis@tfai.vu.lt*

[2] *Vatican Observatory Research Group, Steward Observatory, Tucson, Arizona 85721, U.S.A.; rpboyle@mac.com*

[3] *Chorzow Astronomical Observatory, 41-500 Chorzow, Poland; astrobit@ka.onet.pl*

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Abstract. A project for astrometric and photometric observations of asteroids with the VATT telescope on Mt. Graham is described. One of the most important results is the discovery of the Transneptunian object (420356) Praamžius. We computed its orbit applying 198 optical observations from 2003 February 1 to 2016 January 30. We also followed its orbit searching for minimal distances to Neptune between the years 17 000 and –13 000. Combined with the apparent brightness, the orbit gives the absolute magnitude $M_R = 5.59 \pm 0.37$ mag. Using a typical albedo value of 0.08 for Centaurs and TNOs, we get a diameter of (420356) Praamžius in the range 302–425 km.

Key words: minor planets, asteroids: astrometry, photometry, orbits – minor planets, asteroids: Transneptunian objects: individual: (420356) Praamžius)

1. INTRODUCTION

One of the research projects of the Vatican Observatory is a study of asteroids for a better prediction of their orbits. The observing program on the 1.8 m VATT telescope concentrates on observing the Main Belt and the Centaur group asteroids, Transneptunian objects, as well as on a search for new objects. Details of the first astrometric observations of asteroids and comets with the VATT at the Mt. Graham Observatory (IAU code 290, longitude 109.89201 W, latitude 32.70133 N, altitude 3178 m) were described by Černis et al. (2012a).

Continuing our long-term research program on dynamically interesting asteroids, we discovered some of such objects at the Molėtai and Baldone Observatories: Centaur 2012 DS85 (Černis et al. 2012a), Amor 2010 BT3 (Černis et al. 2012b), Apollo 2008 OS9 (Černis et al. 2010), and two Atens, 2006 SF77 (Černis et al. 2008) and the Potentially Dangerous Asteroid 2000 SG344 (Wlodarczyk 2016).

The asteroid (420356) Praamžius (or 2012 DS85) is a Transneptunian object (TNO) and possibly a dwarf planet orbiting in the Kuiper Belt. It has the second lowest eccentricity among the known TNOs, after 2003 YN179. Praamžius is one of the most recently discovered asteroids for which the numerical designation and

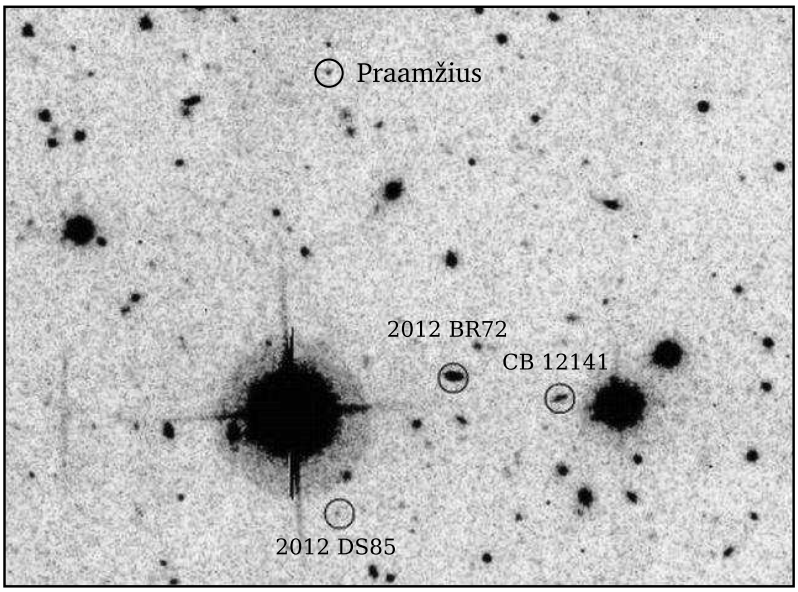

Fig. 1. CCD image of (420356) Praamžius (preliminary designation 2012 BX85). The field size is $2.3' \times 2.7'$, exposure 6 min. Exposed with the VATT on Mt. Graham in the evening of 2012 February 19. Two Main Belt asteroids (2012 BR72 and CB 12141) and the Centaur 2012 DS85 are also identified.

recently the name[1] have been given. Most of its observations were obtained at the Mount Graham Observatory, the discovery site.

2. DISCOVERY OF (420356) PRAAMŽIUS

The asteroid (420356) Praamžius was discovered on 2012 January 23 (Černis & Boyle 2012c), its discovery time and position are listed in Table 1. During the inspection of CCD frames, the asteroid was detected in six 300 s exposures taken sequentially, with about 30 s readout time interval, as a slow moving object in Cancer with motion of $0.04''$/min to the west, to the elongation 152°. This object with $R = 21.6$ mag was identified on 2012 January 10 in the images taken on 2012 January 2. One of the authors (K. Č.) obtained six astrometric measurements of the new object and calculated its approximate positions for the nights preceding and following that of 2012 January 2. The MPC checker showed us that in the same region, $5'$ to the west from the discovered object, the lost object TNO 2010 AH2 might be located. The calculated ephemeris, motion and direction of motion of 2010 AH2 were similar to those of the detected object. However, G. Williams (MPC, 2012 January 11) informed us that the astrometric positions of our object do not fit the orbit of TNO 2010 AH2. After that one of the authors (R. B.) began a new set of CCD observations with the VATT telescope on 2012 January 23. On the next day the object was detected and confirmed by K. Č. in six images. Subsequently, the object was observed on January 25, 27, 29, 30 and 31.

[1] In the religion of ancient Lithuanians, Praamžius was the oldest and highest god related to creation of the world (Straižys & Klimka 1997).

Table 1. Discovery time and position of the asteroid (420356) Praamžius.

Date, UTC	RA	DEC	R mag
2012 January 23.38720	8:43:59.86	+18:14:10.1	21.6

Table 2. First orbit of the asteroid (420356) Praamžius published in MPEC 2012 – B100. a denotes the semimajor axis, e – eccentricity, i – inclination, Ω – longitude of the ascending node, ω – argument of perihelion, M – the mean anomaly and P – orbital period.

Epoch 2012 January 14.0 TT = JDT 2455940.5						
a (au)	e	i (deg)	Ω (deg)	ω (deg)	$M(2000)$ (deg)	P (yr)
43.8250250	0.1024533	1.21870	313.62693	259.33806	286.99245	290

On January 30, G. Williams at the MPC designated the new object as 2012 BX85 and calculated from 14 observations its first preliminary orbit with a period of 290 years.

3. ASTROMETRIC OBSERVATIONS AND THE ORBIT

A total of 199 astrometric points of the asteroid (420356) Praamžius were collected, of which 184 came from the VATT Observatory (IAU code 290) where the asteroid was observed on nights from 2011 December 31 till 2016 January 30 with the 1.8 m f/9.2 reflector, six observations from the Las Campanas Observatory (IAU code 304) obtained between 2013 February 7 and February 9, and nine observations of 2003–2007 from the Apache Point – Sloan Digital Sky Survey (IAU COde 645).

Table 2 lists the elements of the first orbit of (420356) Praamžius = 2012 BX85 published in MPEC 2012 – B100 (issued 2012 January 30, 15:54 UT) that are based on the first 14 observations within 2012 January 23–29. The absolute magnitude H was assumed to be 5.5 mag.

The new orbit of the asteroid was calculated with the operative version of the OrbFit Software OrbFit5.0[2]. The new software includes the debiasing and weighting scheme based on the star catalog position and proper motion corrections in asteroid astrometry by Farnocchia et al. (2015). We also used the DE431 version of JPL's planetary ephemerides together with perturbations of 16 additional massive asteroids according to Farnocchia et al. (2013a,b) in a way similar to that in Wlodarczyk (2015).

Table 3 lists the elements of the new orbit of (420356) Praamžius. The orbit is computed with all 198 astrometric positions (one was rejected) covering the period from 2003 February 1 to 2016 January 30.

In Figure 2 the orbit of the asteroid (420356) Praamžius and of the planets Jupiter, Saturn, Uranus and Neptune are plotted. The positions of the asteroid and planets are presented in the ecliptic plane for the epoch 2016 January 13. The asteroid's orbit never crosses the orbits of the planets because of its low eccentricity.

With the OrbFit software and all observations we also computed a value of

[2] http://adams.dm.unipi.it/∼orbmaint/orbfit/

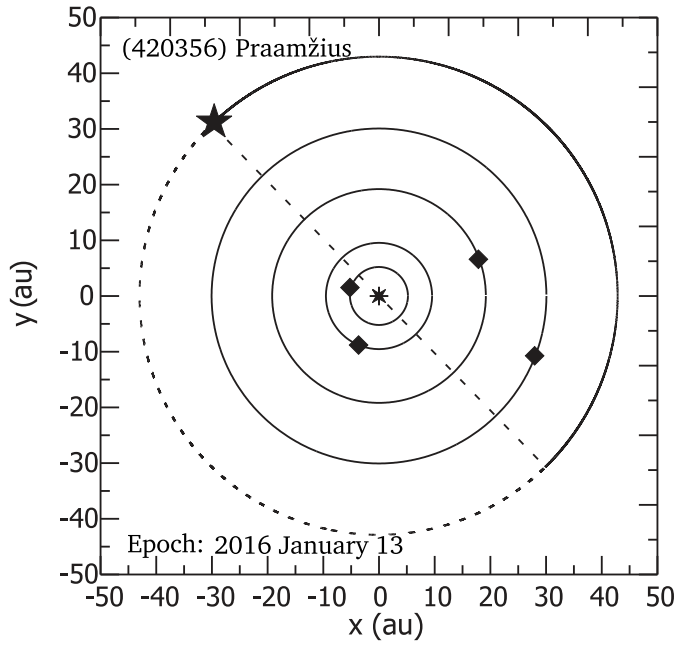

Fig. 2. The orbit of (420356) Praamžius in the ecliptic plane. The positions of the asteroid (star), Jupiter, Saturn, Uranus and Neptune (diamonds) are presented for 2016 January 13. The dashed line denotes the orbit below the ecliptic plane.

Table 3. Asteroid (420356) Praamžius. The two first lines present the Keplerian orbital elements for the epoch JD2457400.5 TDB (2016 January 13) computed with 0 and 16 perturbing asteroids. RMSast = 0.3883″, $H = 5.59 \pm 0.37$ mag. The third line gives uncertainties in the computed elements. The values of RMS, H and uncertainties do not depend on the presence of the perturbing asteroids.

Epoch 2016 January 13.0 TDB = JDT 2457400.5						
a (au)	e	i (deg)	Ω (deg)	ω (deg)	$M(2000)$ (deg)	P (yr)
42.9358755	0.002169180	1.09111996	314.2482376	10.7490	168.4208	281.3394
42.9358753	0.002169185	1.09111998	314.2482376	10.7491	168.4207	281.3394
3.8565E-03	7.6490E-05	4.4695E-04	2.0638E-03	1.9128	1.9214	0.0002

absolute magnitude of Praamžius, $H = 5.588$ mag, with an r.m.s. error of 0.370 mag. Using a typical albedo of 0.08 for Centaurs and TNOs (Moullet et al. 2011), we find the diameter of the asteroid in the range 302–425 km.

The estimated diameter of the asteroid suggests that its shape can be round. According to Mike Brown[3], (420356) Praamžius belongs to the possible dwarf planets. 'Possible' means that we do not know exactly at which diameter the transition from non-round to round shape occurs. In the case of icy satellites this happens between 200 and 400 km, therefore the objects of this size in the Kuiper belt are also expected to be round. A few of these objects could be bigger than

[3] http://web.gps.caltech.edu/∼mbrown/dps.html

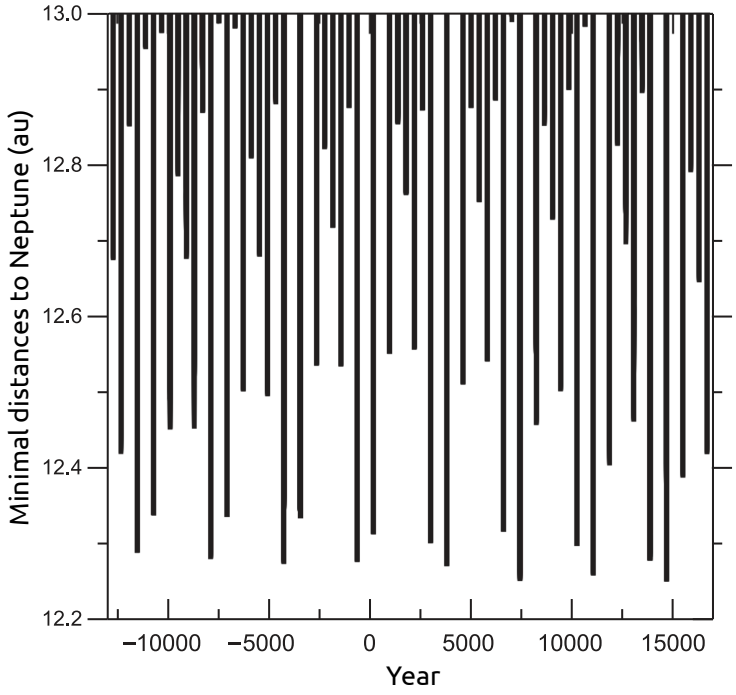

Fig. 3. Minimal distances between the asteroid (420356) Praamžius and Neptune.

Table 4. Minimal distances between the asteroid (420356) Praamžius and Neptune.

Time (yr)	Distance (au)
–11513.967	12.290
–7886.421	12.282
–4258.795	12.275
–631.556	12.278
3801.094	12.272
7428.003	12.253
11054.499	12.260
14681.124	12.252

estimated, consequently, they can be large enough to round themselves.

When the uncertainties of the current asteroid positions are greater than 3σ, in our case $2''$, then new observations are important for the orbit improvement. According to recommendation by the Minor Planet Center[4], we need more observations of the Praamžius asteroid. Since the distance to the asteroid is considerably larger than 1 au and the orbit is almost circular, the apparent brightness of Praamžius remains almost constant at about $V = 22$ mag, accessible for observations with 2 to 4 m class telescopes.

[4] http://www.minorplanetcenter.net/iau/info/FurtherObs.html

4. TIME EVOLUTION OF THE ORBITAL ELEMENTS

Time evolution of the orbital elements of the asteroid was also computed. First, 201 virtual asteroids (clones) were computed using the multiple solution method (Milani et al. 2005a,b) for the 3σ uncertainty around the nominal orbit of the asteroid. Next, we propagated these 201 clones up to 15 000 yr forward and backward in time using the softwares OrbFit v.5.0 and JPL DE431.

Figure 3 shows that between the years –13 000 and +17 000 the asteroid moves in a stable orbit and has regular minimal distances to Neptune. These regular approaches are related to the mean orbital motion resonance 3:5 (the periods 281 and 165 yr). However, the closest approaches of Praamžius to Neptune (Table 4) have a tendency to attain lower values in the future, and this can lead to a systematic change of the asteroid's orbit.

5. RESULTS

One of the most important results obtained with the VATT telescope is the discovery of the asteroid (420356) Praamžius. This asteroid belongs to Transneptunian objects, i.e. objects which orbit the Sun outside Neptune ($a > 30.1$ au).

We computed the orbit and orbital evolution of this asteroid applying 198 optical observations obtained over the period from 2003 February 1 to 2016 January 30. Using the OrbFit Software Package v.5.0, we calculated the approaches of the asteroid to Neptune within 15 000 years forward and backward.

Using a typical albedo value of 0.08 for Centaurs and Transneptunian objects, we get a diameter of (420356) Praamžius in the range 302–425 km.

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