ORBITAL EVOLUTION OF THE ASTEROID 99942 APOPHIS (2004 MN4). Ireneusz Wlodarczyk, Chorzow Astronomical Observatory, e-mail: astrobit@ka.onet.pl.

Introduction: We present orbit and orbital evolution of the asteroid 99942 Apophis (2004 MN4) based on all 8185 total published observations over interval: 2004 March 15.10789 – 2021 May 20.79128: (https://minorplanetcenter.net/iau//mpc.html).

Computation method and results:
To compute the orbital evolution of the asteroid Apophis, we used the publicly available Orb-Fit 5.0.6 software. We used the error model 'vftc17' according to [1].
We used the JPL DE431 Solar System model with an additional 17 massive asteroids as described in [2] and in [3].
Also, we computed non-gravitational parameters A2; and A1 with A2.
Table 1 present computed starting orbital elements of the asteroid Apophis.

Table 1. Starting nominal keplerian elements of asteroid Apophis for error model 'vftc17'for different non-gravitational parameters: A2; and A1 with A2.
Epoch: MJD59200 (2022-Dec.-17.0) TDB.
a=(0.9225247131859+/-9.38E-11) au
(0.9225247206+/-1.38E-08) au
e=0.19150886558+/-1.61E-09
0.19150886209+/-6.68E-09
i=(3.336773322+/-1.82E-07) deg
(3.336773111+/- 4.33E-07) deg
long.node=(204.04198373+/-9.25E-06) deg
(204.0419812+/- 1.03E-05) deg
arg.peric.= (126.65396806+/-9.85E-06) deg
(126.6539719+/-1.21E-05) deg
M=(110.63218094+/-1.33E-06) deg
(110.6321797+/- 1.21E-05) deg
A2=(-2.895+/-0.025)E-14 au/d^2
A1=(- 9.049+/- 16.82) E-13 au/d^2
A2= (-2.893+/- 0.026)E-14 au/d^2
RMS=0.29604"/ 0.29601",
where a is a semimajor axis, e – eccentricity, i – orbital inclination, long node – longitude of ascending node, arg. peric. – argument of perihelion, M – mean anomaly, A1 – non-gravitational radial acceleration parameter, A2 – non-gravitational transverse accelaration parameter.
Top lines denote orbital elements computed with the non gravitational Al parameter, bottom – with the use of the non-gravitational parameter A1 and A2.
We can see, that orbital parameters depend on using kind of the non-gravitational parameter.

Next, we followed the evolution of orbital parameters of asteroid 99942 Apophis in the 100 years forward integration for nominal orbit. We used both models, with A2; and A1, A2 non-gravitational parameters.
We found that after 100 years, differences in cartesian heliocentric coordinates computed with different non-gravitational models exceed in x and y coordinates about 0.004 au, i.e., 600 000 m.
It can be seen from Figs. 1, 2,and 3 that it is difficult to predict the behavior of the nominal orbit of the asteroid Apophis in the next few decades.

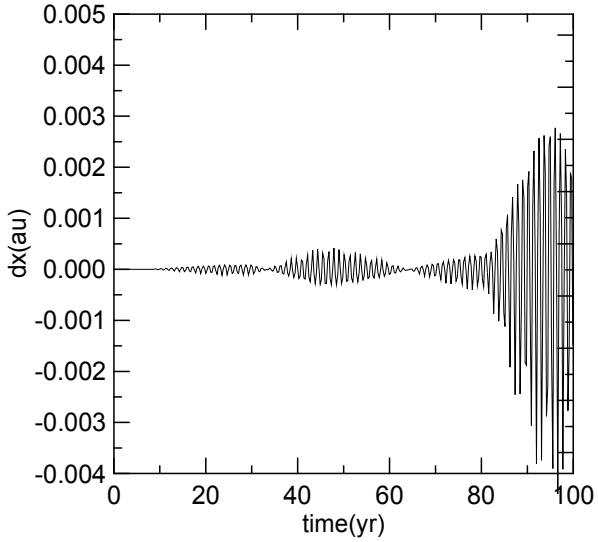

Fig.1. Differences in x cartesian heliocentric coordinate computed with A2 and together with A1 and A2 non-gravitational parameters.

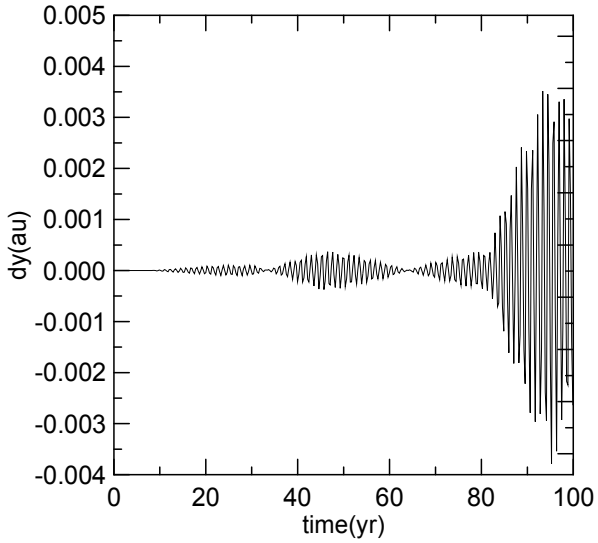

Fig.2. The same as in Fig.1 but differences in y cordinates.

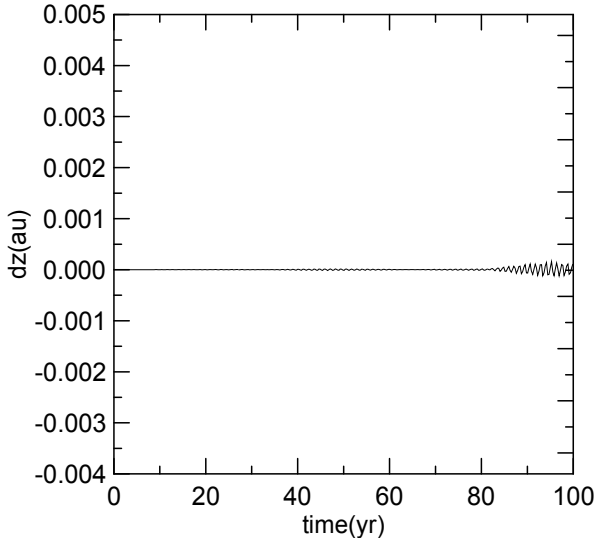

Fig.3. The same as in Fig.1 but differences in z cordinates.

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References: [1] Veres P. et al. (2017), *Icarus*, 296, 139. [2] del Vigna et al. (2018) *A&A*, 617, A61. [3] Farnocchia, D. (2013), *Icarus*, 224,1.