THE ROLE OF THE DISTANCE BETWEEN ORBITAL NODE OF THE ASTEROID AND TRUE ORBIT OF THE EARTH IN COMPUTING CLOSE APPROACHES

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To calculate close approaches to the Earth by asteroids or by comets the following conditions are necessary: a/ to draw a picture of the orbit of asteroid on the ecliptic plane, b/ to compute and to give a picture of distances between ascending or descending node of the asteroid and the true orbit of the Earth in this place, c/ to compute a set of orbits of asteroid which orbital elements differ by the errors of calculating of these elements, d/ to integrate the equations of motion of these orbits, e/ choice only these potentially hazards orbits which rms (O-C) is small (<1" of arc).
In this paper I present the results of computations of a/ and b/ for some selected dangerous asteroids. At that time - March 28, 2004 – there are 2000 SG344, 1997 XR2, 2004 DV24 and 2004 FH. I also present other hazard asteroids: 2004 HW, 2004 HE12, 2004 HK33, 2004 HZ, 2004 JG6 ("apohele") and 2000 JG5 – dangerous asteroid for Mercury. The starting orbital elements of these asteroids were extracted from NEODYS of Andrea Milani (http://newton.dm.unipi.it/cgi-bin/neodys/). The equations of motion of these selected asteroids and the planets with Moon treated as separated body were integrated 1000 years forwards and backwards using Everhart's RA15 (RADAU) method from Mercury Integrator Package v. 6 by J. Chambers [1]. The starting orbital elements of planets were taken using ephemeredes DE405/WAW of prof. Grzegorz Sitarski from Space Research Center Polish Academy of Science in Warsaw [2].
The distance between orbital node of the asteroid an the true orbit of the Earth can be computed as follows. First of all we should compute the distance between the Sun and the orbital node of asteroid as in[3]
at the ascending node: $\upsilon=-\omega$ or $360-\omega$
at the descending node: $\upsilon=180-\omega$, where
υ is the true anomaly, ω – arg. of perihelion, in degrees
then we calculate:
tan(E/2)=sqr((1-e)/(1+e))*tan(υ/2)
r=a*(1-e*cos(E)), where
E – eccentric anomaly, e – orbital eccentricity, r – distance between the Sun and the orbital node of the asteroid.
Then we can compute the distance Δ, between asteroid's orbital node and the orbit of the Earth in that place where the orbit of asteroid crosses the ecliptic plane.
Δ=r_Earth – r_asteroid
In the first approximation you can put for a r_Earth 1AU. For the second approximation you can take for this distance the mean distance between the Earth and the Sun for the Earth's mean anomaly where is orbital node of asteroid. In the third approximation you can use true orbital elements of the Earth for calculating of this distance.
In the following pictures you can see the orbits of some asteroids and the computed distances between the orbital node of asteroid and the orbit of the Earth. Only when this distance is equal 0 impacts are possible.

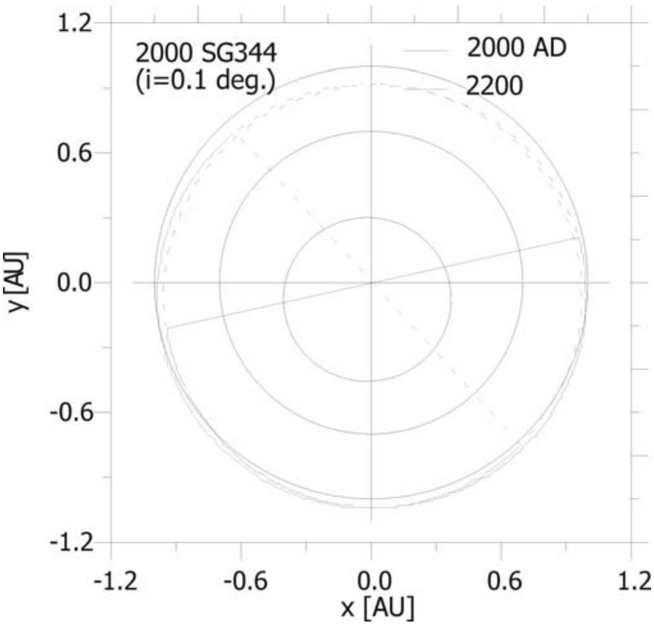

Fig1.jpg

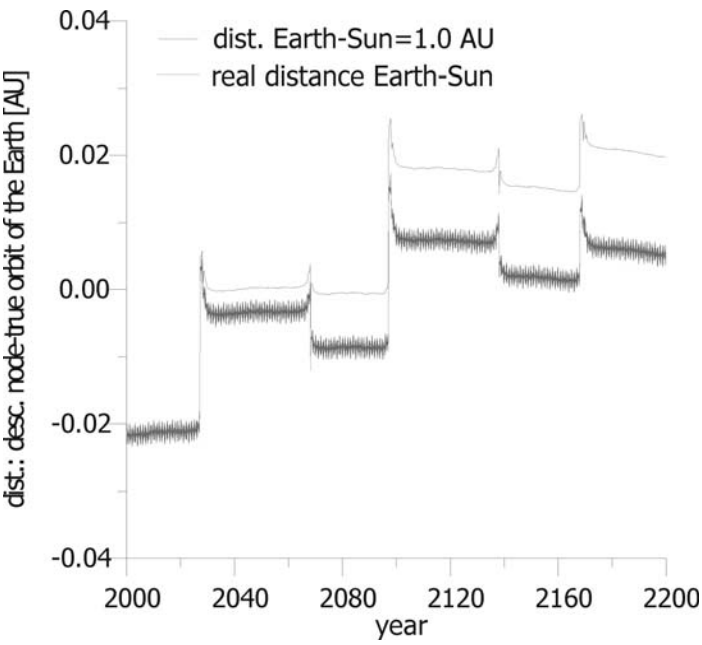

Fig2.jpg

Fig1 and Fig2 show the results of investigation of asteroid 2000 SG344. In the first picture we can see the orbit of this asteroid on the ecliptic plane. In the second one we can see that only in years 2020-2040 and beyond 2140 year the distance between orbital node of asteroid and the Earth is equal 0 AU and this asteroids may hit the Earth only in this time-spans.

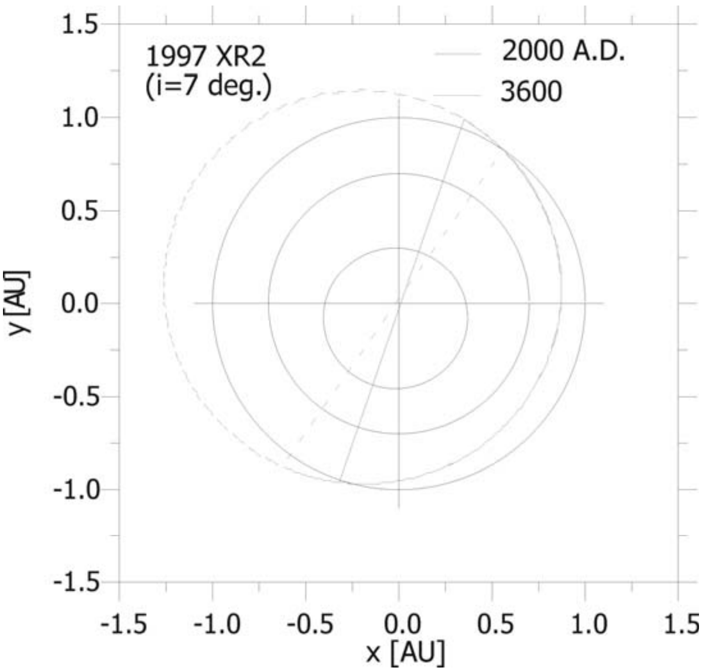

Fig3.jpg

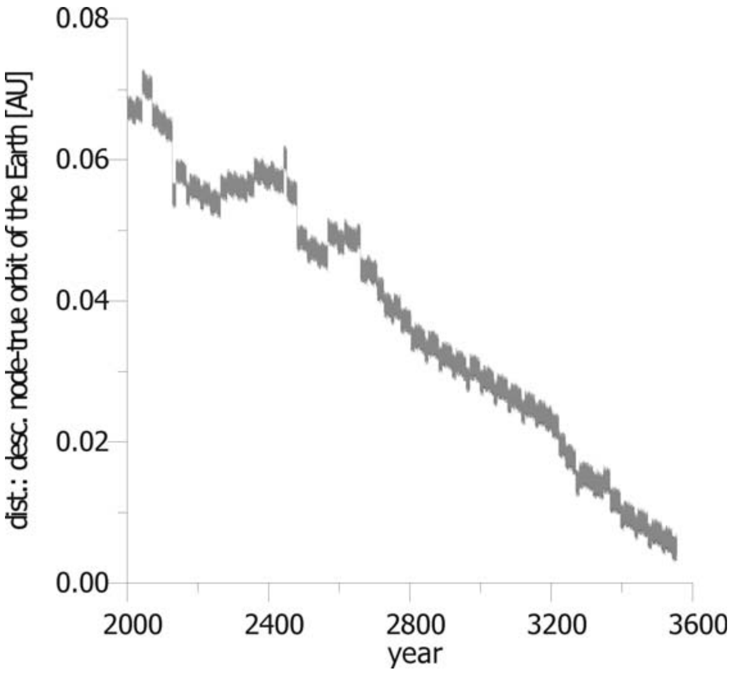

Fig4.jpg

In Fig.3 and Fig.4 one can see the orbit of the 1997 XR2 and the time evolution of the distances between the descending node of asteroid and the Earth. Only after 3600 A.D. this distance is equal .0 AU. In the NASA Ipact Risk Page only this asteroid has the Torino scale equal 1.

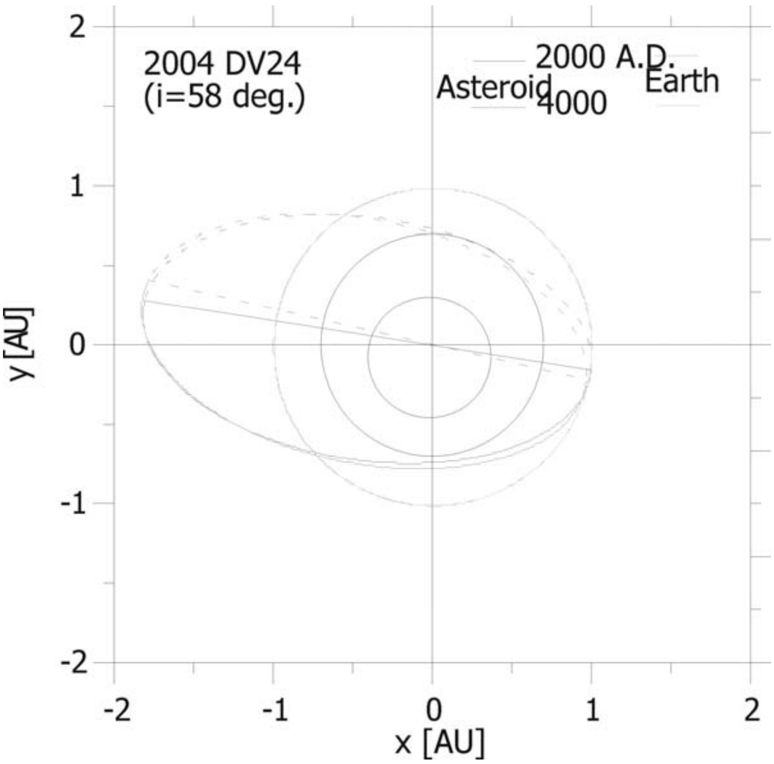

Fig5.jpg

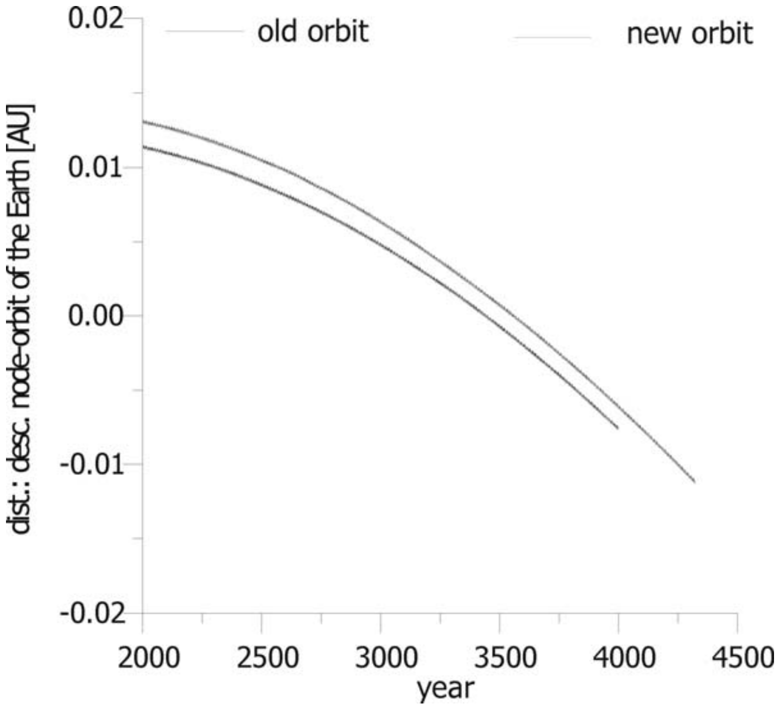

Fig6.jpg

The orbit of the asteroid 2004 DV24 is presented in Fig. 5 and in Fig. 6 we can see that incoming observations of this asteroids move the date for potentially impact forward.

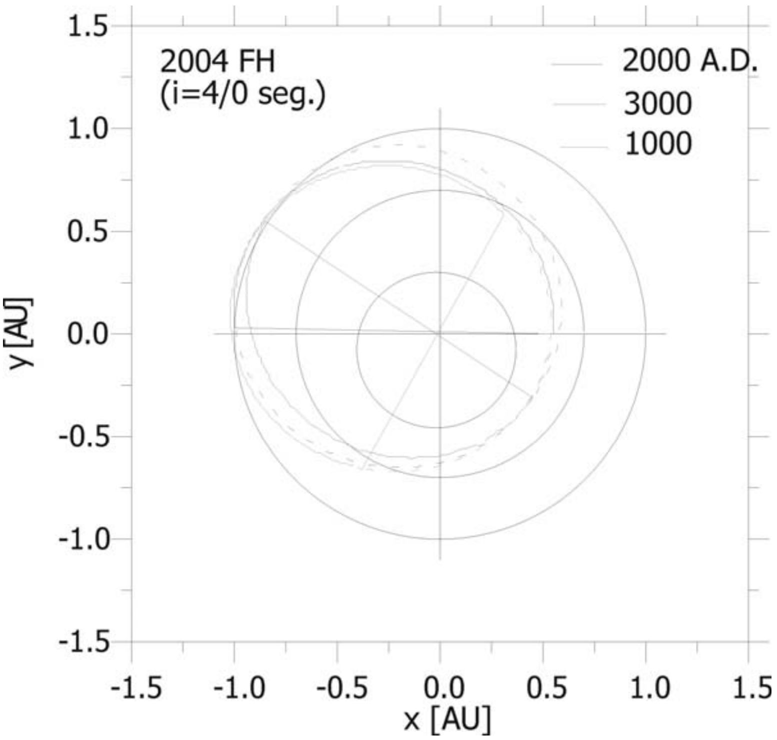

Fig7.jpg

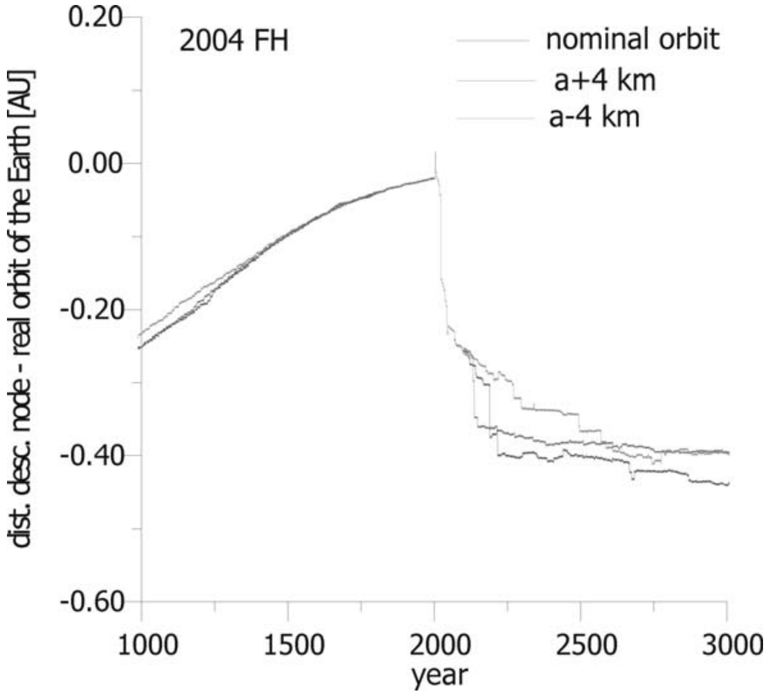

Fig8.jpg

On March 18th, 2004 the minor planet 2004 FH has approached the Earth at dangerously small distance, about 43, 000 km. The orbit of this asteroid and the time evolution of his descending node are presented in Fig. 7 and 8. The computations were made for nominal orbit and for changed orbits with started semi major axes which differ only by 4 km.

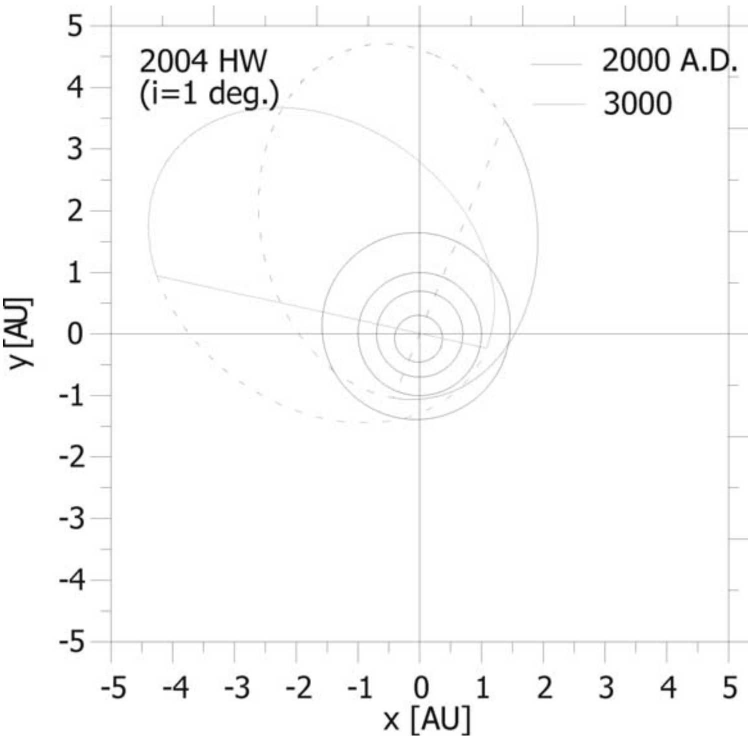

Fig9.jpg

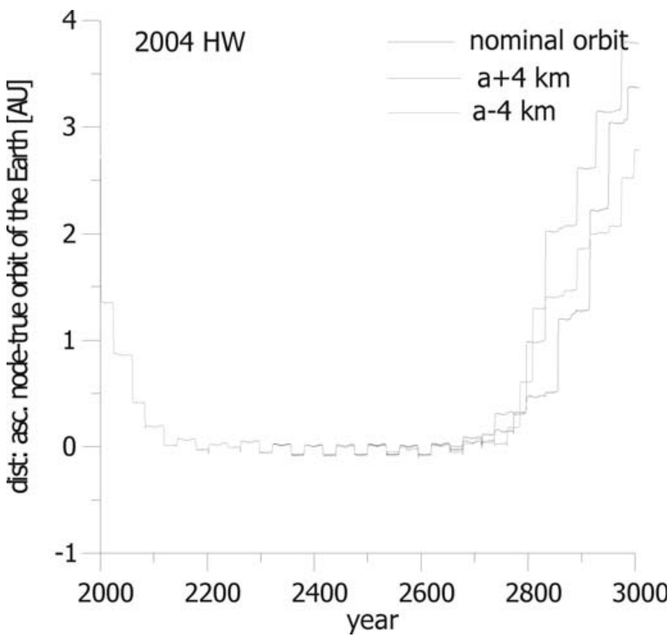

Fig10.jpg

Similar investigations were performed for asteroid 2004 HW in Fig.9 and 10. The collision possibility may occurs between years 2100 and 2750 both for nominal orbit and for changed orbits. Only beyond 2700 yr we can observe different behavior of the orbital node of the asteroid because of chaotic motion of this asteroid. This time I have called in my work the time of stability [4]. We cannot predict the motion of this asteroid after 2700 yr.

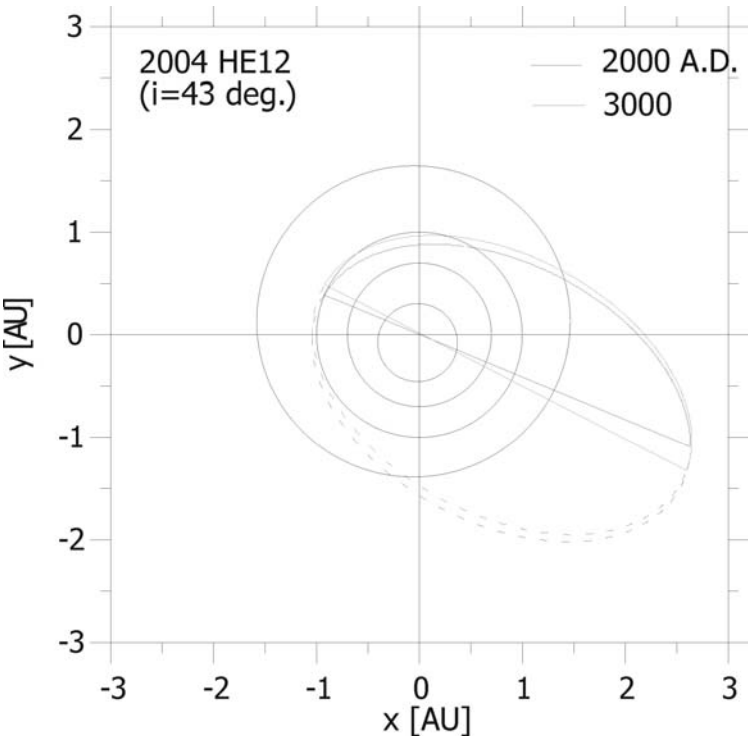

Fig11.jpg

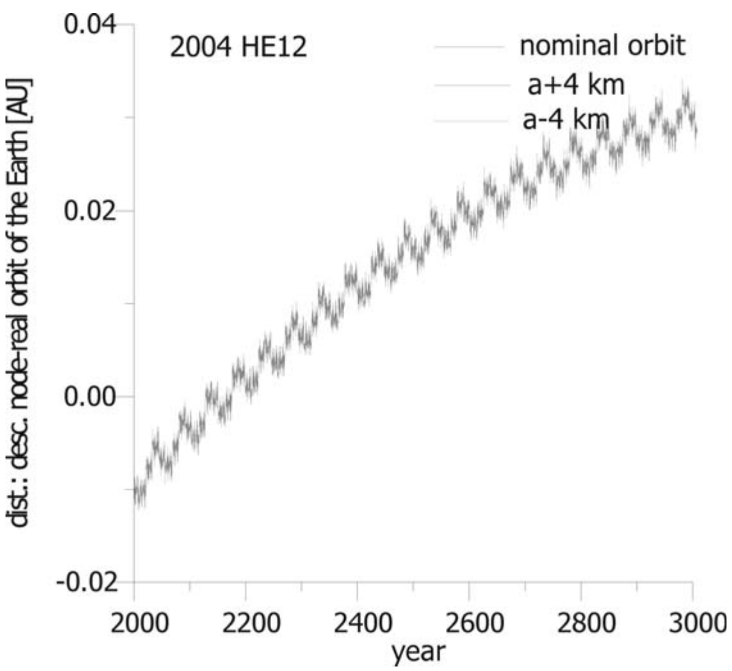

Fig12.jpg

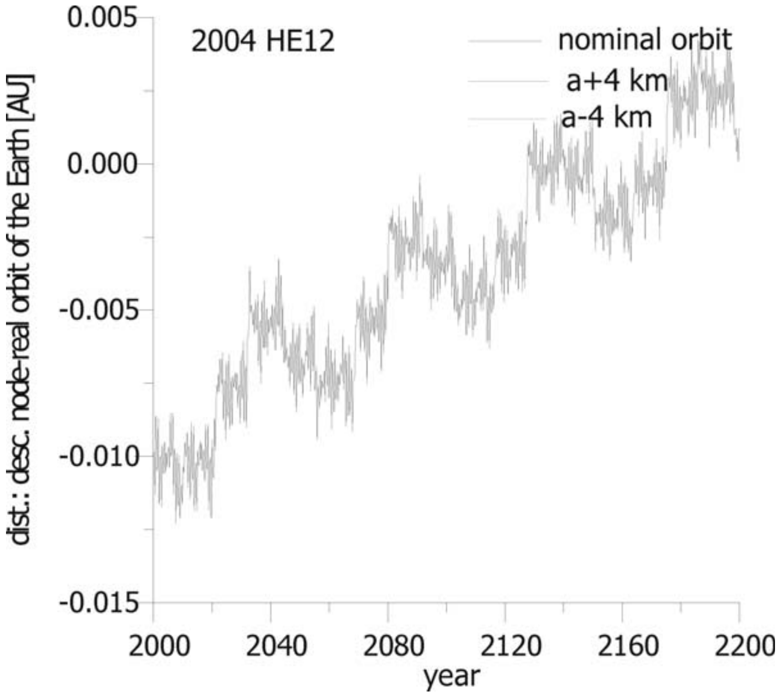

Fig13.jpg

In Fig. 11, 12 and 13 we can see that the asteroid 2004 HE12 may be dangerous for the Earth between years 2120 and 2180.

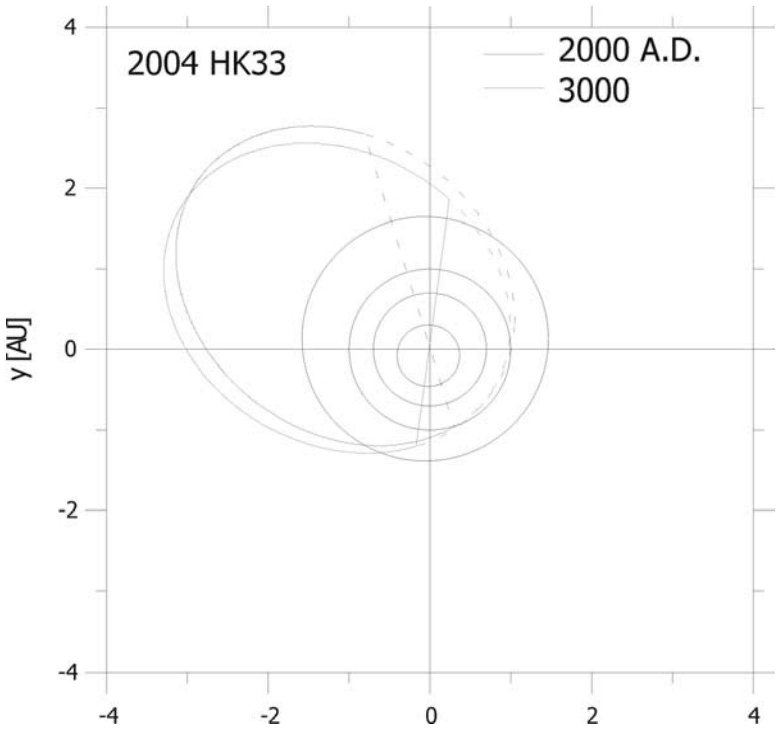

Fig14.jpg

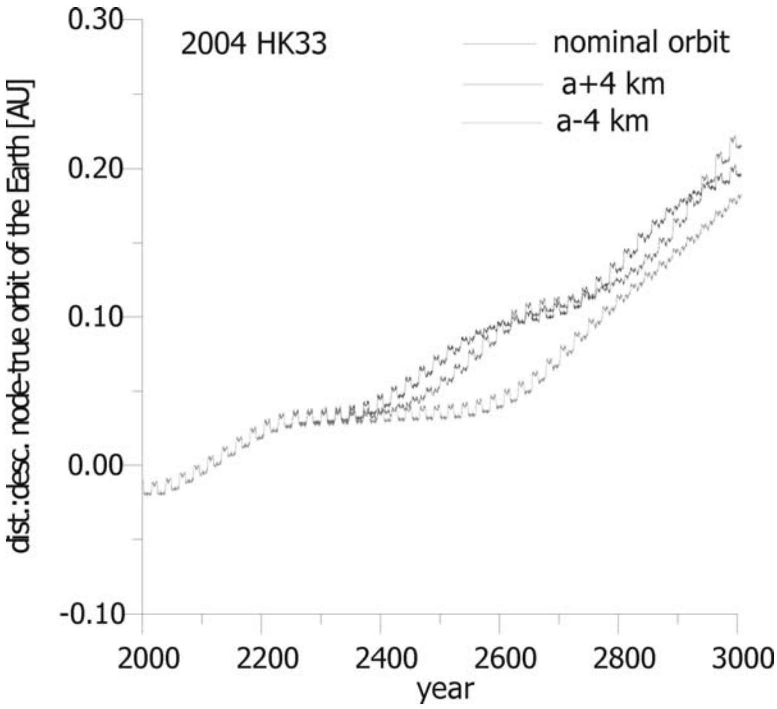

Fig15.jpg

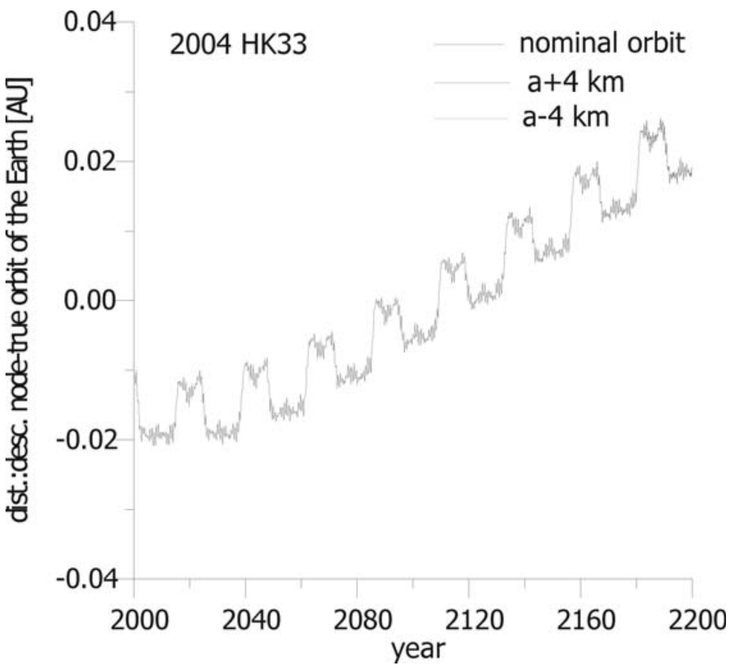

Fig16.jpg

In the similar Figs. 14, 15 and 16 the dangerous small distances between orbital node of the asteroid 2004 HK33 and the orbit of the Earth in the time around 2100 yr were shown.

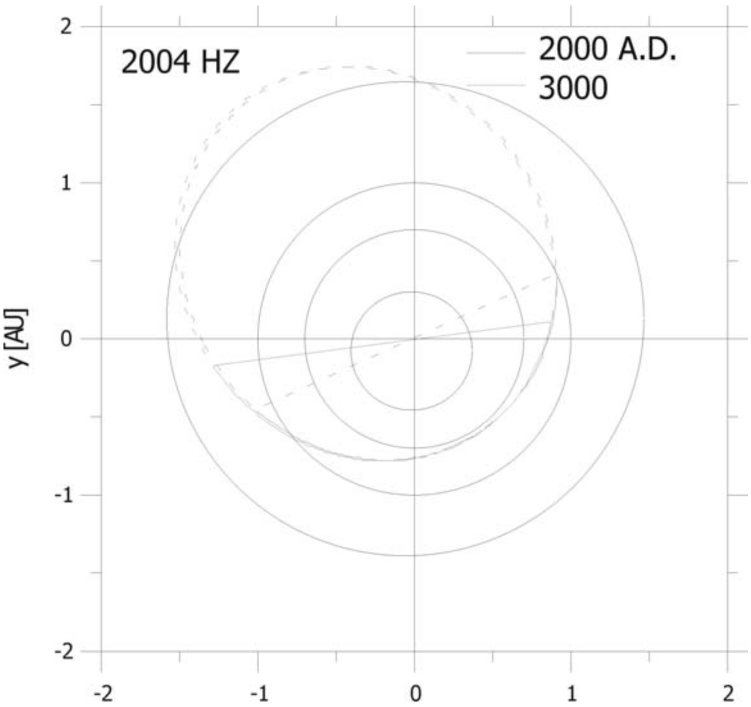

Fig17.jpg

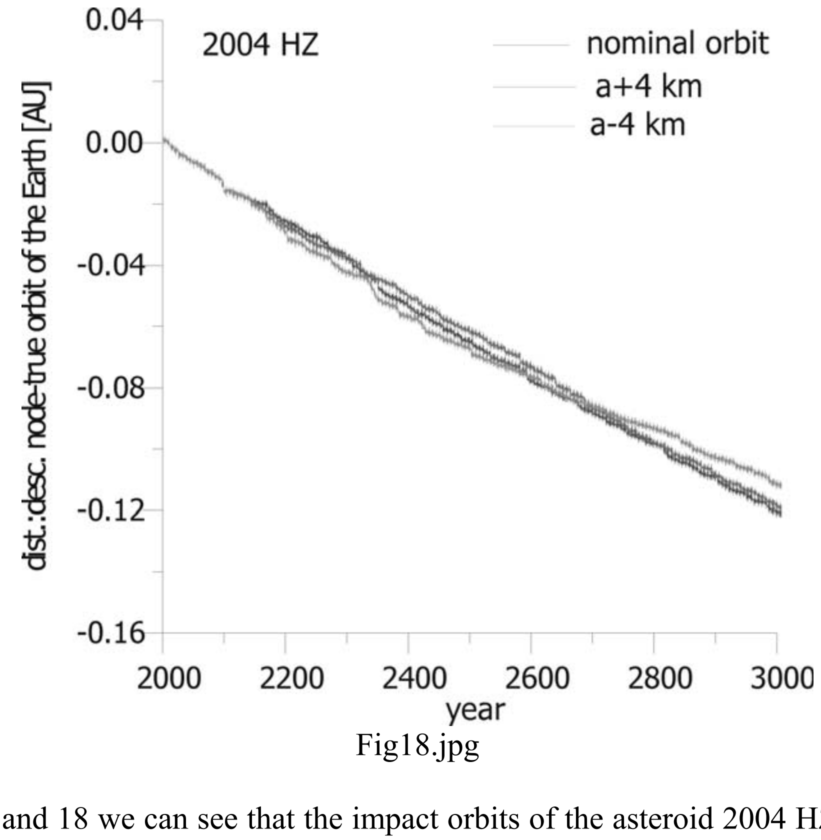

Fig18.jpg

In Figs. 17 and 18 we can see that the impact orbits of the asteroid 2004 HZ may occur in the incoming years.

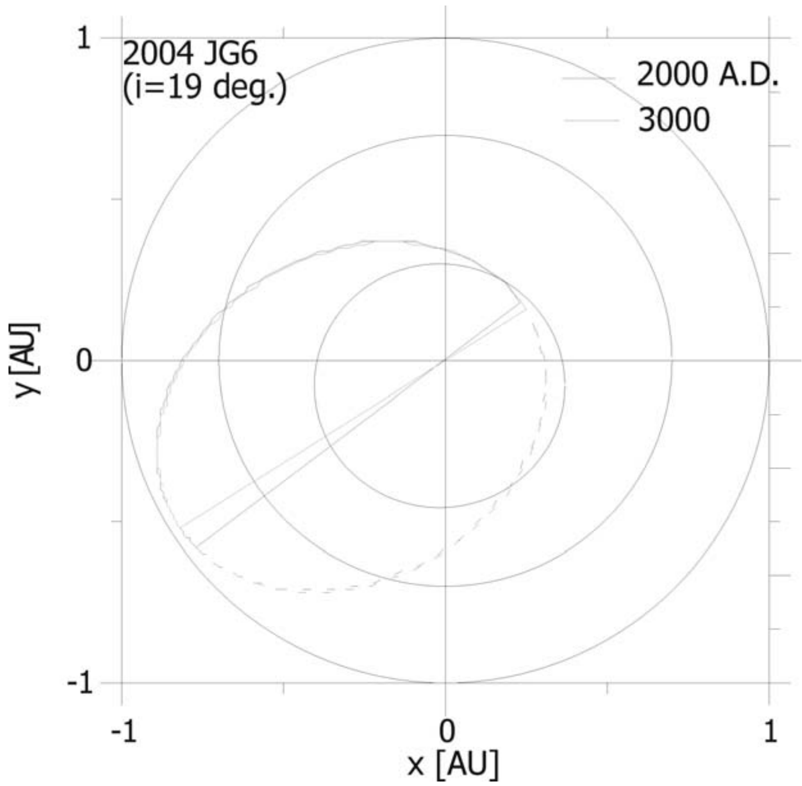

Fig19.jpg

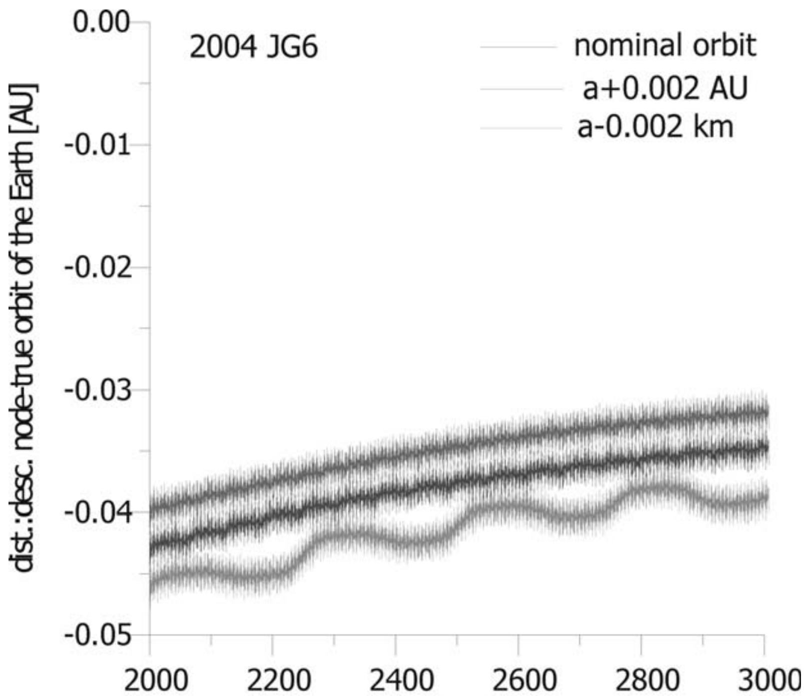

Fig20.jpg

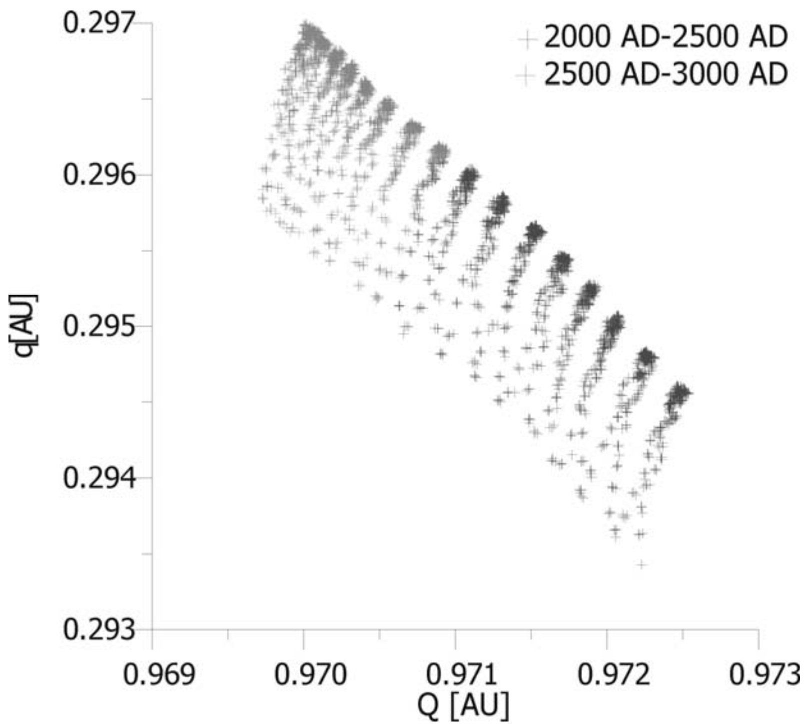

Fig21.jpg

New discovered asteroid – “apohele” – 2004 JG6 with orbit inside the orbit of the Earth is not dangerous for the Earth in the forthcoming years both for the orbital elements of MPCs and Sitarski [5]. Fig. 21 shows that the orbit of 2004 JG6 grows circular and therefore will not cross the orbit of the Earth. Small q means the perihelion distance and Q – aphelion distance.

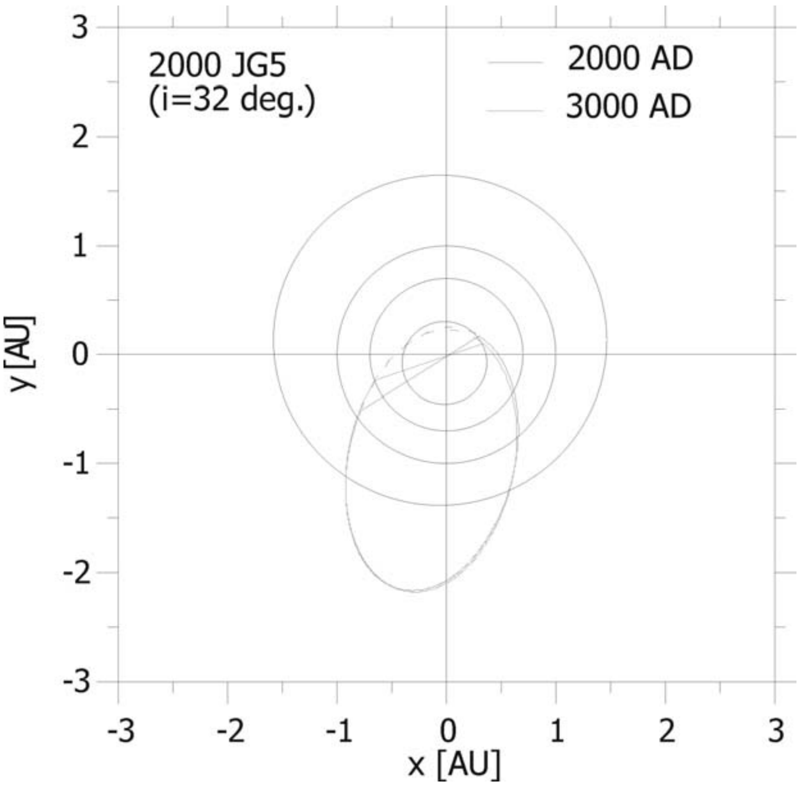

Fig22.jpg

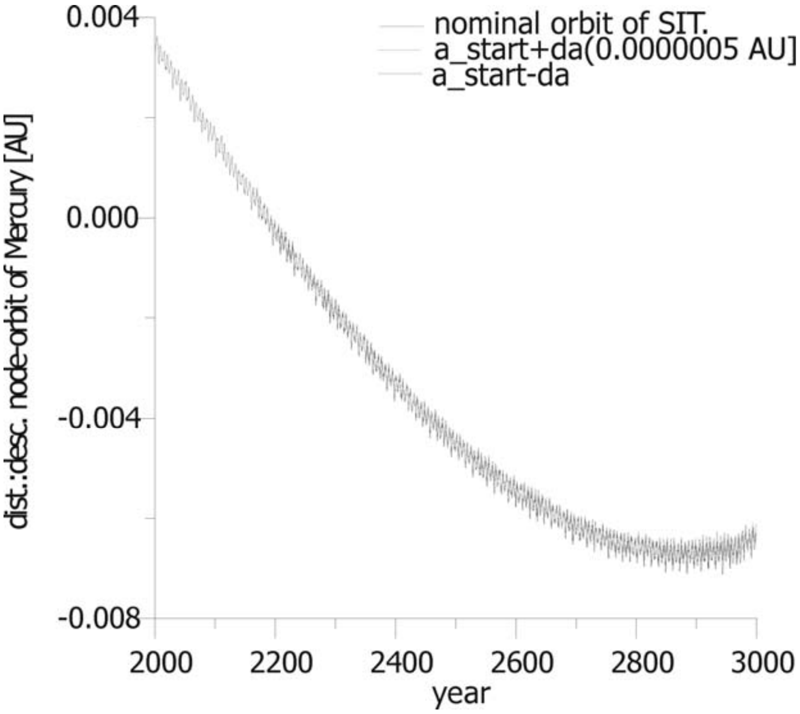

Fig23.jpg

In the similar way we can calculate teh distances between orbital nodes of the asteroid and the true orbits of all terrestrial planets. In Figs. 22 and 23 the results of computations for the asteroid 2000 JG5 were presented. In 2200 yr 2000 JG5 can collide with Mercury.

The results of computation show that distances between orbital nodes of some selected asteroids and the orbit of Earth are good indicators for possible impacts in the future. The similar computations may help to predict the impacts with other terrestrial planets.

REFERENCES

[1] J. E. Chambers, MNRAS, 1999, 304, 793

[2] G. Sitarski, Acta Astron. 2002, 52

[3] J. Meeus, Astronomical Algorithms, 1991, ed. Willmann-Bell, Inc, Richmond, Virginia

[4] I. Wlodarczyk, Acta Astron. 2001, 51, 357

[5] G. Sitarski, 2004, private communication.