The Potentially Dangerous Asteroid (443104) 2013 XK22

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We computed impact solutions of the potentially dangerous asteroid (443104) 2013 XK22 based on 99 optical observations from Dec. 2013 to Jul. 2016. We followed orbit of the asteroid (443104) 2013 XK22 forward in the future research for close approaches with the Earth, which can lead to possible impacts up to the year 2109. We computed non-gravitational parameter $A2 = -2.04 \times 10^{-15}\,\mathrm{au\,d^{-2}}$ with 1σ uncertainty $1.78 \times 10^{-15}\,\mathrm{au\,d^{-2}}$ in the motion of the asteroid (443104) 2013 XK22. Furthermore, the possible impact corridor for the year 2101 is computed and presented. Asteroid (443104) 2013 XK22 belongs to so called possible recovery Near Earth Asteroids and can be recovered in 2028. Therefore, the ephemerides of this asteroid for observational window in 2028 are presented.

1 Introduction

The asteroid (443104) 2013 XK22 was discovered on Dec. 14, 2013 in the Catalina Observatory. It is a potential Earth impactor and since Jun. 10, 2017, it is listed on the top of the CLOMMON2 site reaching Palermo Technical Impact Hazard Scale PS = −4.63 (maximum) provided by the NEODyS[1] (Near Earth Objects Dynamic Site).

To compute possible impact solution of the asteroid (443104) 2013 XK22 with the Earth, we taken into account the ORBFIT software with the JPL DE431 ephemerides, weighting and selecting observations according to the NEODyS, based on the error model (Baer et al., 2011) and the Yarkovsky effects . We searched for the possible impacts using the non-gravitational parameter $A2$, computed directly from observations and with pure gravitational model.

2 Orbit of the (443104) 2013 XK22 asteroid

Currently, as reported at Sept. 17th, 2017, there are 16528 near-Earth asteroids ($q < 1.3$ au): 1232 Atens with orbits similar to that of 2062 Aten ($a < 1.0$ au; $Q > 0.983$ au), 8218 Apollos with orbits crossing the Earth's orbit similar to that of 1862 Apollo ($a > 1.0$ au; $q < 1.017$ au), and 7078 Amors with orbits similar to that of 1221 Amor ($1.017 < q < 1.3$ au). They are listed at the Minor Planet Center (MPC)[2] and at the JPL NASA[3]. The MPC and the JPL NASA classified asteroid (443104) 2013 XK22 as an Apollo-class object.

According to the NEODyS, its absolute magnitude, H is 24.30, with a diameter is about 41 to 92 m. Diameter range is derived from H and assumed albedo for C

[1] http://newton.dm.unipi.it/neodys/index.php?pc=0
[2] http://www.minorplanetcenter.net/iau/lists/Unusual.html
[3] http://neo.jpl.nasa.gov/stats

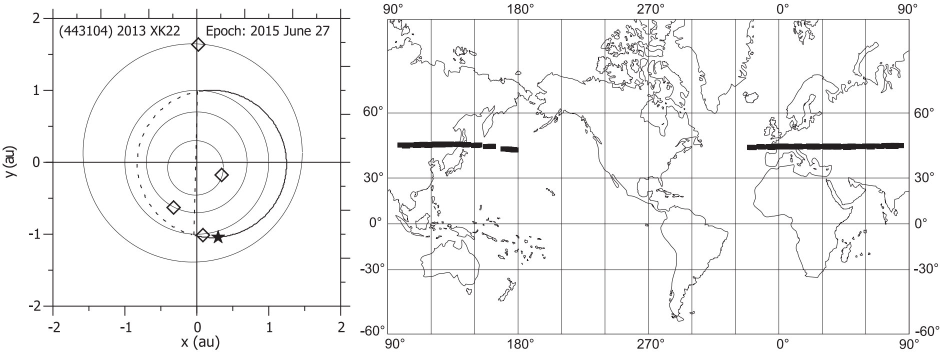

Fig. 1: Left panel: The orbit of (443104) 2013 XK22 in the ecliptic plane. Positions of the asteroid and planets are presented for the epoch: 2015. The dashed line denotes the part of the orbit of (443104) 2013 XK22 below the ecliptic plane. Right panel: The path of risk where the asteroid (443104) 2013 XK22 could impact in the year 2101 as computed with pure gravitational solution.

Table 1: Initial nominal orbital elements of (443104). The angles ω, Ω, and i refer to Equinox J2000.0. Epoch: 2017-Feb-16=JD2457800.5 TDB. Orbital elements are computed without and with different models of non-gravitational parameters. Non-gravitational parameters A_1, A_2 and A_3 are in au d^{-2}.

a (au)	e	i (deg)	Ω (deg)	ω (deg)	M (deg)
Orbital parameters: pure gravitational					
1.27121567017830	0.8899161880103	22.24805218048	265.24122804557	322.16247206883	123.90288870349
1.71072E-09	1.37376E-08	5.46830E-06	9.63971E-06	9.07456E-06	4.68385E-06
Orbital parameters: asteroidal Yarkovsky effect with non-gravitational parameter: $A2$					
1.27121566600255	0.8899161755721	22.24805217754	265.24122890396	322.16247148797	123.90289238858
4.01649E-09	1.74551E-08	5.46867E-06	9.66868E-06	9.08888E-06	5.67039E-06
$A2$=-2.04E-15 ± 1.78E-15					
Orbital parameters: cometary non-gravitational parameters: $A1, A2, A3$					
1.27121565993329	0.8899161886060	22.24805262761	265.2412283364	322.1624640480	123.90289641844
4.64309E-09	1.83536E-08	8.02904E-06	1.68928E-05	1.56936E-05	5.93165E-06
$A1$=5.90493E-12±2.22439E-12; $A2$=-1.62E-15±1.39E-15; $A3$=-1.9466E-13±15.1365E-13					

and S types: 0.04 and 0.20 respectively. C-type asteroids are most common type of known asteroids, about 75% of them. They contain a large amount of carbon. S-type asteroids consist mainly of iron-magnesium silicates. 17% of asteroids are of this type.

To compute the orbit of the asteroid and ephemerides for different dynamical cases we used the freely available ORBFIT software v.5.0[4]. This new version includes the new error model based on Baer et al. (2011). In all computations, we follow the same method of the weighting and selection of observations that is being used by the NEODyS site (Milani et al., 2005a,b) and by Wlodarczyk (2015). We used the JPL DE431 and additionally 25 perturbing asteroids according to Farnocchia et al. (2013).

Fig. 1 left panel presents the orbit of (443104) 2013 XK22 in the ecliptic plane. Positions of the asteroid and planets are presented for the epoch: 2015 Jun. 27.

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

The dashed line denotes the part of the orbit below the ecliptic plane. Tab. 1 lists computed Keplerian orbital elements of the asteroid (443104) 2013 XK22 with their uncertainties. The computed absolute magnitude is H=24.164±0.494 mag.

3 Impacts

Fig. 1 right panel presents the path of risk where the asteroid (443104) 2013 XK22 could impact in the year 2101. Computations are made for the ballistic orbit, i.e. with pure gravitational solution.

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