The Potentially Dangerous Asteroid (29075) 1950 DA

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We computed impact solutions of the potentially dangerous asteroid (29075) 1950 DA based on 768 optical observations from 1950 February 22.23014 to 2021 July 4.618248, and twelve radar observations from 2001 March 03 to 2012 May 01. We followed the asteroid's orbit (29075) 1950 DA forward in the future, searching for close approaches with the Earth, which can lead to possible impacts up to the year 2881. Earlier, in Wlodarczyk (2020), we presented the current state of calculations of possible collisions for two more asteroids: (99942) Apophis and (410777) 2009 FD. The latter two no longer pose a threat to the Earth.

1 Introduction

Asteroid (29075) 1950 DA was discovered at Mount Hamilton on 1950 February 22 by C. A. Wirtanen. Orbit type of asteroid is Apollo and Potentially Hazardous Asteroid. According to the NEODyS website[1] the asteroid (29075) 1950 DA belongs to the so-called 'special group' of asteroids which contains one more asteroid (101955) Bennu now. They are subject to an individual procedure for calculating possible collisions with Earth. To compute the possible impact solution of the asteroid (29075) 1950 DA with the Earth, we used the OrbFit software with the JPL DE431 ephemerides. Observations were weighted and selected according to the Near-Earth Objects Dynamic Site (NEODyS)[2] procedure. In our work we include two different error models, the influence of 4 and 17 additional massive asteroids, and the Yarkovsky effect. We searched for the possible impacts using A_2 parameter, computed directly from observations. A_2 is a non-gravitational transverse acceleration parameter.

2 Results

To compute the possible collisions of the asteroid (29075) 1950 DA with the Earth, we used the publicly available OrbFit v.5.0.5 and 5.0.7 software[3]. These versions can compute orbits and search for possible impacts with the Earth using dynamical parameters connected to the non-gravitational perturbations. We used two error models *fcct14* (Baer et al., 2011; Farnocchia et al., 2015) and *vftc17* (Vereš et al., 2017). A new error model *vfcc17* is based on further statistical analysis of the astrometric errors for the major asteroid surveys compared to the older error model *fcct14*.

[1] https://newton.spacedys.com/neodys/index.php?pc=4.1&ots=t
[2] https://newton.spacedys.com/neodys/index.php?pc=4.1
[3] http://adams.dm.unipi.it/*rbmaint/orbfit/*

Tab. 1: Initial nominal keplerian orbital elements, named in the first row, and their units given in the second row, of the (29075) DA asteroid. Computations are made for three cases: A, B and C, which are listed in 3rd, 7th, and 11th row respectively. Values of elements are given always in the first row following the row with the case description, while values of errors - in the second row after the case description. Absolut magnitude H, RMS of the orbital fit, and A_2 parameter are also given in the following rows. The angles ω, Ω, and i refer to Equinox J2000.0. Epoch: 2020 December 17=JD2459200.5 TDB.

a	e	i	Ω	ω	M
(au)		(deg)	(deg)	(deg)	(deg)
case A: 4 additional massive asteroids, and *fcct14* error model					
1.698665730456	0.50773603423	12.167334070	356.655846458	224.683153902	319.922524449
1.195×10^{-9}	3.139×10^{-8}	4.544×10^{-6}	8.054×10^{-6}	9.269×10^{-6}	2.716×10^{-6}
H=17.103, RMS=0.4860", A_2=$(-5.137\pm1.242)\times10^{-15}$au d^{-2}					
case B: 17 additional massive asteroids, and *fcct14* error model					
1.698665727456	0.50773603535	12.167333962	356.655845783	224.683154513	319.922526212
1.195×10^{-9}	3.139×10^{-8}	4.544×10^{-6}	8.054×10^{-6}	9.269×10^{-6}	2.716×10^{-6}
H=17.103, RMS=0.4860", A_2=$(-6.161\pm1.242)\times10^{-15}$au d^{-2}					
case C: 17 additional massive asteroids, and *vftc17* error model					
1.698665726374	0.507736067	12.167339420	356.655842356	224.683162804	319.922527906
1.003×10^{-9}	2.101×10^{-8}	4.213×10^{-6}	6.395×10^{-6}	7.434×10^{-6}	2.213×10^{-6}
H=17.187, RMS=0.4855", A_2=$(-6.912\pm1.235)\times10^{-15}$au d^{-2}					

To compute possible impacts of the asteroid (29075) 1950 DA with the Earth, we integrated the equation of motions until JD2775000.5 TDT, i.e. to 2885 August 4. We used the parameter $\sigma_{\rm LOV}$=5 and calculated 601 clones (VAs). We used the JPL DE431 Solar System model and an additional four first numbered asteroids and 17 massive asteroids as described in Del Vigna et al. (2018) and Farnocchia et al. (2013). We used the selection and weighting of observations according to the NEODyS site[4].

In Tab 1. we present orbital elements computed with different error models and the different number of perturbing asteroids.

Tab. 2: Impact table for the asteroid (29075) 1950 DA, and for three perturbed cases given by number of asteroids (first column), and error model (second column). Computations are made for the DE431 version of JPL's planetary ephemerides. Expected energy denotes impact energy multiplied by impact probability. Units are in megatons MT, and 1 MT=4.184×10^{15} J.

Number of asteroids	Error model	Date, UTC *LOV*	σ probability	Impact MT	Expected energy	PS
4	*fcct14*	2880/03/16.992	1.512	2.52×10^{-5}	2.81	-1.97
17	*fcct14*	2880/03/16.992	2.339	5.70×10^{-6}	0.636	-2.62
17	*vftc17*	2880/03/16.992	2.757	1.87×10^{-6}	0.185	-3.14

We can see that non-gravitational transverse acceleration parameter $A2$ has a small value, about -6.0×10^{-15} au/d^2, and a slight differ using different error models and additional massive perturbing asteroids. Table 2 presents an impact risk for different errors and the different number of perturbing asteroids. $\sigma_{\rm LOV}$ denotes

[4] https://newton.spacedys.com/neodys/

the position along the line of variation, LOV, in the σ space. Values of σ are here in the interval [-5,5]. Table 2 also presents the probability of Earth impact and Palermo Scale (PS). PS is the new hazard scale Chesley et al. (2002). We can see that date of possible impact is the same for different error models and additional perturbing massive asteroids. However, the probability of Earth's impact has the largest value for four additional perturbing massive asteroids.

Later, in Proceedings of the 53rd Lunar and Planetary Science Conference on March 7-11, 2022 (Wlodarczyk, 2022) we published the results of possible asteroid (29075) collisions with the Earth based on a longer observation arc, until 2021 Dec 03.143961, and a larger number of observations, 960. We got from this data A_2=(-7.299±1.216)$\times10^{-15}$au d^{-2}. We computed possible impact in 2880/03/16.992 with the probability 7.49×10^{-7}. A_2 has changed from the previous A_2=(-6.912±1.235)$\times10^{-15}$au d^{-2} to A_2=(-7.299±1.216)$\times10^{-15}$au d^{-2}. Collision probability decreased from 1.87×10^{-6} to 7.49×10^{-7}.

On August 8, 2022, the observational arc and number of observations have not changed since the publication in Wlodarczyk (2022).

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References

Baer, J., Chesley, S. R., Milani, A., *Icarus* **212**, 1, 438 (2011)

Chesley, S. R., et al., *Icarus* **159**, 2, 423 (2002)

Del Vigna, A., et al., *A&A* **617**, A61 (2018)

Farnocchia, D., Chesley, S. R., Chamberlin, A. B., Tholen, D. J., *Icarus* **245**, 94 (2015)

Farnocchia, D., et al., *Icarus* **224**, 192 (2013)

Vereš, P., Farnocchia, D., Chesley, S. R., Chamberlin, A. B., *Icarus* **296**, 139 (2017)

Wlodarczyk, I., *Bulgarian Astronomical Journal* **32**, 27 (2020)

Wlodarczyk, I., in LPI Contributions, *LPI Contributions*, volume 2678, 2023 (2022)