

## **Software Complex “Asteroids and Comets” at the Site of the Institute of Applied Astronomy RAS**

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The software complex “Asteroids and Comets” offers an opportunity to solve a set of research problems connected with asteroids and comets in web-access mode. The complex not only provides the user with a certain amount of information on the issues, but also gives him the opportunity to perform some calculations and research in remote access. The list of these problems is rather wide. One of the key part of the complex is the computing-analytical package intended to predict approaches of minor bodies to the Earth and the Moon, and to estimate the collision probability. To improve object orbital elements the optical and radar observations from the catalogue of the Minor Planet Centre (USA, Cambridge) as well as radar observations of Quasar VLBI network are used.

**Keywords:** Asteroids, comets, orbits, observations.

The software complex “Asteroids and Comets” of the Small bodies of the Solar system Laboratory of IAA RAS is developed to create a Russian source of information, especially about the dynamics of asteroids and comets, based primarily on original domestic research and developments; to assist professional researchers and amateurs in the study of small bodies of the Solar system. It offers the opportunity to address a number of research tasks related to asteroids and comets: determination of the minimum distance between the two orbits, calculation of encounters with other objects, visualization orbits, ephemeris calculation of search, etc. An user is able to enter their own orbital object data. Each section contains a detailed description of the scope of the issues which is sufficient for the correct use of the tools provided by the site. The website contains also publications of the staff, protection seminars, links to interesting work, etc.

The list of the problems solved by the complex is the following.

Structure of the software complex “Asteroids and Comets”

<b>Information about minor bodies</b>	<b>Asteroid and cometary hazard</b>	<b>Tasks</b>
<p><i>Asteroids</i></p> <p><i>General information</i></p> <p>Search by fragment name</p> <p>List of named asteroids</p> <p>Types of asteroid orbits</p> <p>Groups and families of asteroids</p> <p>Proper elements of some asteroids</p> <p>Masses and density of some asteroids</p> <p><i>Information about each asteroid</i></p> <p>History of discovery and naming</p> <p>Observations</p> <p>Physical and orbital parameters</p>	<p><i>Real bodies</i></p> <p>Examples of calculations of circumstances of collision with Earth of real bodies</p> <p><i>Model bodies</i></p> <p>Calculation of circumstances of approaching or falling asteroids, which orbital and physical parameters set by the user randomly</p> <p><i>Work in real time</i></p> <p>Operation of the bench in real time.</p>	<p><i>General information</i></p> <p>Additional orbit parameters</p> <p>Proper orbit parameters</p> <p>Commensurability of the motion with other objects and Tisserand criterion</p> <p>Transfer of orbit parameters to new date</p> <p>Minimal distance between two orbits</p> <p>Encounters with big planets and other bodies</p> <p>Orbit visualization</p> <p>Construct of initial orbit</p> <p>Searching ephemerides</p>
<p><i>Comets</i></p> <p><i>General information</i></p> <p>Search by fragment name</p> <p>List of comets</p> <p>Types of comet orbits</p> <p>Proper elements of some comets</p> <p>Masses and density of some comets</p> <p><i>Information about each comet</i></p> <p>History of discovery and naming</p> <p>Observations</p> <p>Physical and orbital parameters</p>	<p><i>Encounters of bodies with the Earth and Moon</i></p> <p>The table of the past and forthcoming approaches of bodies which is automatically updated by calendar date in of the package</p>	<p><i>Additional tasks</i></p> <p>Text editor</p> <p>Translation of calendar date in Julian days and back</p> <p>Observatories</p>



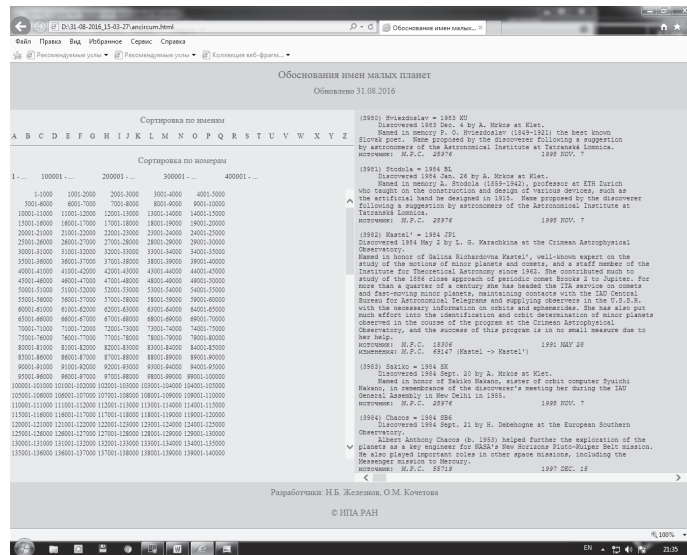


Fig. 2. Lists of numbered asteroids with information about their discoveries and history of assignment of a name

The section “Information on small bodies” — a user has possibility to obtain information on physical and orbital parameters of asteroids and comets at the website, to compile their own list of object’s observations and to calculate object’s orbit, to get history of object’s discovery and naming (Fig. 1, 2). Besides, an user can choose asteroids and comets according to orbital types, families of asteroids, and other information.

The section “Tasks” lists the tasks for which users have web access. The list of such tasks is very wide. The example of the user inquiries at a formulation them tasks is shown in Fig. 3, 4.

The section occupies a special place, “Asteroid and cometary hazard”, which is a tool that handles real time received information about the discovery and observations of potentially hazardous bodies, predicts their motion and in case a body enters the earth’s atmosphere, recreates the whole scenario of impending disaster. A software package was developed for handling existing in database information about the potentially hazardous bodies and received via communication channels information about the discovering of a new hazardous bodies and their observations. On the basis of available data of a prediction of possible rapprochements or collisions with the Earth and the Moon on the next several revolutions of the body around the Sun and their probabilities. In addition, the complex may serve as an instrument for calculation of circumstances of approaching or falling of bodies, which orbital and physical parameters set by the user randomly (Fig. 5).

Fig. 3. Example of a typical tab for introduction of the input data necessary for the solution of tasks of the user

Fig. 4. Tab for input of parameters of the orbit of an object not switched on databases of the complex

The chronological table of the past and forthcoming encounters of bodies is provided in the section “Rapprochements of Bodies with Earth and Moon”. Content of the table is updated in real time correspondingly by the results of operation of the package.

**ПАДЕНИЕ НА ЗЕМЛЮ ГИПОТЕТИЧЕСКОГО НЕБЕСНОГО ТЕЛА, ПАРАМЕТРЫ КОТОРОГО ЗАРАНЕЕ ЗАДАНЫ** Мб

Дата и время падения тела (или воздушного взрыва)  
 Дата падения: год 2012, месяц 11, день 15  
 Время падения (Московское время): часы 12, минуты 00, секунды 00.0

Географические координаты места падения (или воздушного взрыва)  
 Восточная долгота (от 0° до 360°): градусы 37, минуты 02, секунды 40.0  
 Широта (от -90° до +90°): градусы +55, минуты 23, секунды 12.0

Параметры траектории падения  
 Наклон скорости тела к горизонтальной плоскости (от -90° до 0°): -45.0  
 Азимут направления скорости (от 0° до 360°): 45.0 (отсчитывается в плоскости горизонта от направления на север по часовой стрелке)  
 Топоцентрическая скорость (от 11 до 72 км/с): 15.0

Размер тела и высвобождаемая энергия  
 Диаметр (м): 250.0  
 Энергия (килотонны): 500000.0  
(одна из этих двух величин может быть задана произвольно, а вторую можно оставить не заданной, ее величина будет вычислиться)

Обстоятельства падения тела  
 Время до столкновения (сутки): 3.0  
 Высота взрыва (км): 0.0  
 Высота входа в атмосферу на заданной широте (км): 100.0

Модель движения астероида  
 Численное интегрирование:  
 Меркурий  Венера  баристрент Земли+Луна [ Земля  Луна]  
 Марс  Юпитер  Сатурн  Уран  Нептун  
 Плутон  Церера  Паллада  Веста  
 релятивистские члены от Солнца  световое давление  
 скатие Солнца  скатие Земли

Fig. 5. Calculation of circumstances of approaching or falling of bodies, which orbital and physical parameters set by the user randomly

Таблица сближений астероидов с Землей и Луной

ТХТ-файл таблицы    Архив сближений

Дата и время обновления 14.09.2016 06:45

Объект	Диаметр фотонетрический (м)	С чем сближается	Дата сближения	Минимальное расстояние (в единицах расстояния Земля-Луна)	Относительная скорость (км/с)	MOID на дату сближения (в единицах расстояния Земля-Луна)	Вероятность столкновения
2016 OZ2	160-701	Луна	2016 11 24.43025	48.76	11.66	32.43	0.00E+00
2005 TF	223-956	Земля	2016 11 23.81296	36.98	5.00	36.52	0.00E+00
2016 OZ2	160-701	Земля	2016 11 23.72171	49.58	10.87	33.67	0.00E+00
2012 XE17	211-913	Земля	2016 11 21.21986	73.20	11.33	64.42	0.00E+00
2005 TF	223-956	Луна	2016 11 20.47993	36.99	4.56	36.91	0.00E+00
2012 XE17	211-913	Луна	2016 11 20.05471	72.58	10.81	64.76	0.00E+00
2002 UQ12	75-378	Земля	2016 11 19.28325	84.08	14.97	10.28	0.00E+00
433953	147-638	Луна	2016 11 19.03671	17.75	7.18	12.81	0.00E+00
433953	147-638	Земля	2016 11 18.62846	18.51	6.35	0.21	0.00E+00
2002 UQ12	75-378	Луна	2016 11 17.40528	84.93	14.19	10.02	0.00E+00
2016 LC9	7-36	Земля	2016 11 15.41291	50.51	4.61	3.94	0.00E+00
2004 KB	129-692	Земля	2016 11 11.92150	9.34	13.19	8.70	0.00E+00
2004 KB	129-692	Луна	2016 11 11.60998	9.74	13.50	9.27	0.00E+00
2016 LC9	7-36	Луна	2016 11 10.58767	51.27	4.21	19.70	0.00E+00
2016 LA49	6-29	Луна	2016 11 08.32164	57.92	4.79	0.00	0.00E+00
2016 QH44	101-460	Земля	2016 11 07.81245	42.13	10.24	9.80	0.00E+00
2007 RO17	25-31	Луна	2016 11 07.77927	50.11	8.98	14.22	0.00E+00
2016 QH44	101-460	Луна	2016 11 06.39873	41.55	10.78	10.03	0.00E+00

Fig. 6. Fragment of the table of past and forthcoming approaches of asteroids with the Earth and Moon

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