

## INFORMATION ON ORBITAL ELEMENTS OF THE NUMBERED MINOR PLANETS FOR 2022

We stop preparation of the Ephemerides of Minor Planets (EMP) for 2022 and for the next years. The main reason is the outdated form of the table format of ephemerides. The package AMPLE allows to calculate the ephemerides of minor planets in convenient view.

We intend to keep the table "Orbital elements of the numbered minor planets". We plan update orbital elements after each publication of observations by MPC.

Elements of all numbered minor planets (585 962) have been determined by IAA. The sets of elements are given for the epoch Aug. 9, 2022. They were determined as a result of orbit improving on the base of all kinds of optical observations available in the catalog of observations of the Minor Planet Center on Aug. 10, 2021 (radar observations have not been used at this stage).

When using these data it is necessary to take into consideration the following:

1) corrections to the initial sets of elements were determined by the least square fit of weighted conditional equations. In so doing, the observations made before 1901 were assigned weight equal to 1/16, the observations made during the time interval from 1901 to 1950 were assigned weight equal to 1/9, the observations made during the time interval from 1951 to 1995 were assigned weight equal to 1/4, and at last the observations starting from 1996 were considered as having unit weight;

2) observations of only standard accuracy were used for orbit improvement;

3) observations in right ascension and in declination were considered as independent, so that conditional equation, e.g. in right ascension, could be excluded by "the three sigma criterion" from solution whereas equation in declination could be used or vice versa;

4) observation is considered as used, if both conditional equations in right ascension and in declination or at least one of them are used for finding solution;

The elements of the numbered minor planets are given with respect to the ecliptic and equinox J2000.0. The computation of osculating elements for the new standard epoch JDT 2459800.5 = 2022 August 9.0 TT was carried out by numerical integration of relativistic equations of motion in rectangular coordinates taking into account the perturbations from Mercury to Neptune and from Pluto, Ceres, Pallas, and Vesta. Coordinates and masses of perturbing planets were taken from *DE* 440. The perturbations from the Earth and the Moon were considered separately.

The following Table gives the format of presentation of elements in files.

Number, name	$H$ , m	$G$	$M$ , °	$\omega$ , °	$\Omega$ , °	$i$ , °	$e$	$n$ , °/day	$a$ , a. u.	TE	date	$m$ , m
1	2	3	4	5	6	7	8	9	10	11	12	13
1 Ceres	3.53	0.15	334.32718	73.53159	80.26645	10.58679	0.0786359	0.21418055	2.7666191	22	—	—
2 Pallas	4.22	0.15	315.09112	310.84262	172.91791	34.92714	0.2299865	0.21385068	2.7694633	22	—	—
3 Juno	5.28	0.15	306.62240	247.80395	169.84594	12.99223	0.2567749	0.22585733	2.6704222	22	9 6.9	8.2
4 Vesta	3.31	0.15	61.19231	151.25771	103.80085	7.14078	0.0884018	0.27151121	2.3619872	22	8 25.7	6.1

The first column of the Table gives the number and the name or principal provisional designation of each minor planet. The second one gives the absolute magnitude,  $H$ , that is, the brightness averaged over rotation for minor planets having known lightcurves and reduced to unit heliocentric and geocentric distances and to zero phase angle. The third column gives the slope parameter,  $G$ . Parameters  $H$  and  $G$  are provided by the Minor Planet Center.

The orbital elements (mean anomaly,  $M$ , argument of perihelion,  $\omega$ , longitude of ascending node,  $\Omega$ , inclination,  $i$ , eccentricity,  $e$ , mean motion,  $n$ , and semi-major axis,  $a$ ) are given in the columns from 4 to 10. The eleventh column of the Table headed TE contains last two digits of the year 2022. The 12th and the 13th columns of the Table contain opposition date of minor planet in 2022 (number of month and date) and its apparent magnitude  $m$  for the nearest standard Julian day number preceding the opposition. A dash indicates that there is no opposition in 2022.

The catalogues of elements can be find in two variants. 1) one file contains elements for all 585 962 minor planets; its name is 'el\_585962.txt'; 2) there are a number of files, each of them contains 4000 minor planets. The names of such files have view 'el22\_000001\_004000.txt', 'el22\_004001\_008000.txt' and so on.

The data are presented as TXT files and ZIP files.

One can take elements of numbered minor planets using softwares AMPLE (<https://iaaras.ru/dept/lbss/ample/>), they are obtained in IAARAS and based on *DE* 440, and AMPLE3 (<https://iaaras.ru/dept/lbss/ample3/>), they are taken in the Minor Planet Center and based on *DE* 405.

The mentioned catalogues contain neither the errors of the orbital elements no RMS values. These information one can find for each minor planet in Russian in "Catalogue of small bodies" (<https://iaaras.ru/dept/lbss/mpc/>) or in English in "Small Bodies Catalogue" <https://iaaras.ru/en/dept/lbss/mpc/#q=999>).