

# Halley - Electronic Catalogue of Comets

Yu. S. Bondarenko

Institute of Applied Astronomy RAS, Russian Federation (bondarenko@ipa.nw.ru)

## Abstract

Halley - Electronic Catalogue of Comets is software for management and working with the comets database, containing Keplerian orbital elements derived from existing catalogues of comets [1] and elements of short-period comets, calculated using the original method [2] developed at the IAA RAS (Institute of Applied Astronomy Russian Academy of Sciences). Also the comets database contains non-gravitational and physical parameters of the comets, additional parameters used in the improvement, and other data. The database is updated in case the new data become available. The tasks performed by the electronic catalogue, in addition to database management, include calculation of the orbital evolution of comets and visualization of comet dynamics, detection of close approaches with the major planets in a given time interval, as well as a number of other tasks.

## 1. Introduction

Ever-increasing number of observations of comets, the discovery of new comets, in addition to the existing problems of cataloging, such as collecting, storing various information about comets and fast data search poses the problem of operative determining and improvement of their orbits and rapid delivery of new elements to researchers and observers, preferably at the most convenient form for use. Convenience in this case may also include the additional tools to perform calculations with the available data. Thus, the problems listed above pose the complex task the organization of management and work with the orbital and other data. The solution of this problem is the Electronic Catalogue of Comets, named for the creator of the first catalogue of cometary orbits - Edmond Halley.

## 2. Brief description

Designed for Microsoft Windows, the electronic catalogue is built into the GUI, which simplifies user

interaction with the application. Comets database is the basis of the catalogue provides information about all available apparitions of comets, so its management has a special place when working with the catalogue. Each record of database contains the old and the new provisional designation, number and name of the comet, type of cometary orbits, epoch, date of perihelion passage, and the dates of the first and the last observations, elements of the Keplerian orbit, the number of observations used for obtaining the orbit, the version of ephemerides of major planets used, perturbations taken into account when determining the orbit, components of non-gravitational acceleration, asymmetric outgassing about perihelion, and values of photocenter displacement, the values of the root mean square errors of observations, references to the source of catalogue data, history of the apparitions of a comet, time of changing the record and physical parameters of the comet. The catalogue allows the user to perform the following operations with the database records: a) adding new records; b) editing existing records; c) creating copies of existing records with the possibility of their editing; d) removing the existing records; e) importing and exporting records; f) updating or restoring database records from the IAA RAS Internet server.

Work with the catalogue begins with selecting the records from the database. After specifying the necessary conditions index, a user query is sent to the database. The "output area" creates a table with the found results. Selected records by default are in ascending order of the first element. Also, the user has the ability to customize a convenient form of the output table.

It is important to note that any transaction relating to the work with the comets database is carried out only with the selected records. Current version of the electronic catalogue has the following features to work with comets database: a) saving the information from the database to a file; b) output the additional information of the selected records such as date of reopening, the number of observations in this

apparition, brightness outbursts, etc. (only if such information is contained in the relevant records); c) visualization of a three-dimensional projection of the comet's orbits of selected records within a specified period of time (Fig. 1); d) calculating the position and velocity, Keplerian orbital elements, data on close-approaches and perihelion passages of comets of selected records at the given moment. It is important to note that in each type of the selected task it is possible to set proper preferences.

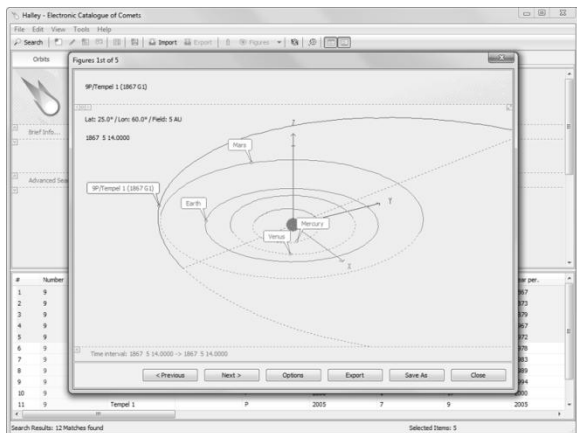


Figure 1: Figures task.

### 3. Implementation

The basic software core of the electronic catalogue has been implemented in FORTRAN (Intel® Fortran Compiler used). This allows producing high-precision integration of the equations of motion of comets. The gravitational perturbations from all major planets and Pluto are taken into account in the equations of motion. Coordinates of the perturbing planets are computed on a basis of numerical ephemerides DE406 [3]. Equations of motion include relativistic perturbations from the Sun. Perturbations of the Earth and Moon are taken into account separately. Marsden's model [4] was taken as a model of non-gravitational accelerations with perihelion-maximum offset parameter [5]. Numerical integration of the equations of motion is performed by Everhart's method of 11-th order with automatic control of step size [6]. High accuracy of numerical integration is achieved through the use of the modified Encke's method. The modification consists of performing the change of the osculation epoch at each step of integration. The parameters of the unperturbed motion are calculated with quadruple precision by using variables with 32 decimals.

Database management is performed using the SQLite library. The catalogue is intended for use with a personal computer with Microsoft Windows® XP, Vista or 7.

### 4. Support and distribution

Halley - Electronic Catalogue of Comets contains updatable database of comets. It is assumed that regular updates of the database are stored on the Internet server of IAA RAS and that they automatically added to the database of catalogue. Preparation of new elements of comets, observed during the current month, is produced in IAA RAS using specially designed software. Also new features as well as "bug" fixes will be made. The website of catalogue (<http://www.ipa.nw.ru/halley>) contains the basic information about the catalogue and the latest news.

### References

- [1] Marsden, B., Williams, G.: Catalogue of Cometary Orbits, Cambridge, 16th ed., 2005.
- [2] Bondarenko, Yu., Medvedev, Yu.: Long-term numerical theories of comet motion, Solar System Research, Vol. 44, No. 2, pp. 144-151, 2010.
- [3] Standish, E.: JPL Planetary and lunar ephemeris DE405/LE405, JPL Interoffice Memorandum 312. F-98-04, 1998.
- [4] Marsden, B., Sekanina Z., Yeomans D.: Comets and nongravita-tional forces, Astron. J., Vol. 78, pp. 211–225, 1973.
- [5] Sekanina, Z.: Outgassing asymmetry of periodic Comet Encke. I – Apparitions 1924–1984, Astron. J., Vol. 95, pp. 911–924, 1988.
- [6] Everhart, E.: Implicit single-sequence methods for integrating orbits, Celest. Mech., Vol. 10, – 35 p. 1974.