System Galactica for Solving the Problems of Bodies Interaction

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The system Galactica is developed to solving *N*-body problems, in which bodies are interacting by the Newton's gravity law or by the Coulomb's law. The addition of system with other laws of interaction is planned in future. The system is based on high-accuracy method for integration of differential equations. It is available at site http://www.ikz.ru/~smulski/GalactcW/. The description of Galactica is in the files GalDiscrp.pdf and GalDiscrE.pdf in Russian and English, respectively. It allows even the novice researcher to formulate and to solve the problems by using the Galactica.

The system Galactica at site http://www.ikz.ru/~smulski/GalactcW/ is designed to work on a personal computer (PC). We are working at present (13.03.2012) to establish a system of free access to work on a supercomputer. The information about it will be posted on the above website. For the statement of tasks, analysis of their results and for solving problems with small time computing it is possible to use the system Galactica on the PC. The system of free access on a supercomputer can be used for great tasks: with the large computing time, for a large number of bodies or at extended length of number (34 decimal places).

The program Galactica have be used to solve the next problems.

1. The evolution of the orbits of the planets and the Moon for 100 million years [1] - [2]. Such integration of differential equations for such a period we performed the first time. The periods and amplitudes of the oscillations of the bodies' orbits were obtained and the stability of the Solar System is established.

As it is well-known in the literature such computing, performed by other methods, are given the unstable orbits. It has served as the reason of a conclusion about instability of Solar system and has justified introduction of chaos for an explanation of the unexplored phenomena.

2. For researching influence of the Sun to the Earth climate the missions to the Sun are planning. The task of optimum flight to the Sun was considered [3]. It is determined that the gravimanoeuvre at the Venus reduces by 20% of the initial velocity of the spacecraft.

In this paper the computational technology is developed as with the help of the program Galactica to start space apparatus without corrective engines for running the planned mission.

3. The evolution of the asteroid Apophis in 1000 years [4] - [6]. According to our calculations the minimum distance Apophis with the Earth will occur April 13, 2029. We found that in the coming 1000 years this Apophis's approach will be minimal.

The calculations carried out by scientists other methods do not give a reliable representation of the Apophis's motion after April 13, 2029. Therefore, these authors are looking for the probability of collision of Apophis with Earth in the 2036-37 years.

4. The evolution of the asteroid 1950DA for 1000 years [7]. The experts of NASA are thought that there is the probability of encounter the asteroid 1950DA with the Earth in 2880. We have found that the asteroid 1950 DA to the time period in 1000 will double-pass near the Earth at a distance of about 2.25 million km: in 2641 and 2962.

5. The transformation of the trajectories of the asteroid Apophis and 1950DA in the orbits of satellites [4] - [7]. With program Galactica the asteroids' parameters are identified which necessary to transform them into satellites and the evolution of these satellites are studied.

6. The compound model of the Earth's rotation and the evolution of its axis [2], [8]. The Earth is considered as set of several bodies located on a equator plane. The movement of one of these bodies simulates the motion of Earth's rotation axis. The evolution of motion of the Earth's axis was calculated for 110 thousand years, the oscillation periods are determined and established that the Earth's axis precesses relative to the moving axis of the Earth's orbit.

7. The compound model of the Sun rotation and its influence on the planet [9] - [12]. The Sun rotates with a period of 25.38 days. With the program Galactica the influence of compound model of the solar rotation and other bodies to the nearest planets was found. The calculations give the excess rotation of Mercury's perihelion, which is explained by other mechanisms.

These studies found that all the observed motions in the Solar system under the gravitational interactions are completely determined by Newton's law of gravity.

8. Multilayer ring structures [13]. The structure consists of several rings, each containing several bodies. The evolution of several variants of these structures was calculated and the stable and unstable structures were received. At the destruction of the unstable structure the two bodies are ejected from it in opposite directions. The expansion of bodies takes place at high velocities. Such ejections occur in the clusters of stars, galaxies and at the appearance of supernovae. Them are explained by explosions of these objects. In real, the phenomenon under consideration is occurred due to the Newtonian interaction.

A report on the possibilities of the Galactica program at the exhibition "Scientific, technical and innovative achievements of Russia", May 12-15, 2011, Madrid, Spain, is available on YouTyube in the form of a video: https://youtu.be/uDc-DmTCcZk and in the form of a presentation: https://youtu.be/Z17B3F4oPEI.

The analogical system Horizons of free access for solving the dynamics of the Solar system was created NASA (http://ssd.jpl.nasa.gov/?horizons). It is effectively used as for realization of space missions within NASA, and for solving problems of the external researchers.

The system Horizons is approximate. In it the position of planets and the Moon are based on the approximation of the hundreds thousands of observations. Formally, the system, except for the gravitational Newton’s force, in the standard dynamic model (SDM) is taken into account a number of small additional influencing factors. However, their influence is actually canceled by the fact that the results of calculations are approximated on observational data. The position of the existing celestial bodies, whose motion is approximated, is calculated with sufficient accuracy. If it is necessary to calculate the motion of any body, the system Horizons integrates movement only given body and the motion of other bodies are taken from the approximate system. If the body is not included in the base of the approximation of the system, or is considered outside the framework of observation, the accuracy of the calculation of motion worsens over time at a distance from the base of the observations.

The program Galactica, developed by us, solves the problem of body’s motion as Newton's gravity interacting material points. In it the precision method of integration of the equations is used. To calculate the initial conditions are specified, and the base of the observations is not used. Therefore, using the Galactica one can compute the motion of bodies that have not previously been observed, and in any configuration and in any quantity.

Since the system Horizons is approximate, for the planets and the Moon, having a base of observations for hundreds of years, the results of the system Horizons may be more accurate than the system of Galactica. This is true if the calculation time is within the time base of observations. In other cases, the opportunity of system Galactica surpass opportunities of system Horizons. Further, upon completion of the work to refine the initial data and initial conditions of the planets and the Moon, the system Galactica will exceed system Horizons in the above mentioned cases.

Galactica differs from systems Horizons by other principles and methods of calculation. This can be especially useful, when there will be a necessity to check up important decisions for mankind. In addition, Galactica can solve such problems, for which the system Horizons is not intended. With it one can solve various problems for space research, as well as simulated tasks that arise in the study of the evolution of the Earth, the planets and the Solar system.

Coulomb’s interactions are exemplified axisymmetric models of oxygen and helium [13]. They consist of a positively charged nucleus and symmetrically arranged on the plane of the electrons. With the module of system Galactica for the Coulomb’s interaction is studied the motion of particles in such axisymmetric models. It is discussed, as axially symmetric structure of the atom

can be used to create his other geometries. In the future, such studies will increase the degree of determinacy of microworld.

For the correct formulation and solution of the interaction of bodies it is need a lot of knowledge in the field of mechanics and mathematics. As this deep knowledge the researcher in concrete area has no, he usually seeks to use existing mathematical tool that is applied to solve such problems. This allows him, by analogy with known problems, to use the techniques for the preparation of the problem to the solution, to execute and to monitor solutions, to control its errors, as well as post-processing of results. At creation of the program Galactica and at its application for the solution of various tasks these steps have been implemented. Very often they require solving additional problems in the mechanics or numerical or analytical form. Some of these techniques can be attributed to the general, and some – only to certain tasks. Therefore advisable the solved problems: their statement, the input and initial data and the received results are also made available.

At the present time in the system Galactica, there are examples of tasks performed only by us. Subsequently, the set of the solved problems will be supplemented by other researchers. This will enable each new investigator, based on reliable tools and techniques quickly and successfully to put and to solve the new problems. Users of the system can not only be experienced professionals, but also capable pupils and students.

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