Brief information about the project

Name of the project	AP14970491 «Investigation of the three-body problem with anisotropically varying masses using methods of analytical calculations». (0122PK00746)
Relevance	Real cosmic bodies are non-stationary. Over time, their masses, sizes, shapes and the structure of the distribution of masses inside the bodies. These processes occur intensively in double and multiple systems. In this regard, the problem of three bodies with masses varying isotropically at different rates in the general case is investigated. The bodies are considered as spherical bodies of variable radius with spherical mass distribution, which interact as material points. Based on the Meshchersky equation, to obtain the equations of motion of the problem of three bodies with variable masses, whose masses change anotropically at different rates in the presence of reactive forces in an absolute rectangular Cartesian coordinate system. Further, the equations of motion of the problem under consideration in the relative coordinate system and the equations of motion of the problem in Jacobi coordinates are obtained. The problem is investigated on the basis of perturbation theory based on aperiodic motion along a quasiconic section, in analogues of the second system of Poincare elements. Due to the anisotropically changing masses, reactive forces appear in this case, which significantly complicate the task. Unlike other works of the project, the effect of reactive force on the movement of bodies is shown. The methods of canonical convolution theory, the mathematical apparatus of the theory of non-autonomous canonical systems, modern methods of computer algebra Mathematica and numerical methods are widely used.
Purpose	The aim of the project is to study the centuries-old differences in the problem of three bodies in the case of different patterns of changes in body mass. Change in masses and clarification of the effect of the resulting reactive forces on the dynamic evolution of this system.
Objectives	1) Obtaining various differential equations convenient for studying secular perturbations of the problem of three bodies with variable masses. 2) Investigation of canonical equations of secular perturbations in a system of various variables. 3) Obtain a classification and isolate the secular part of the perturbation function to a lesser parametric degree with second-order accuracy by updating the classical scheme 4) Obtaining differential equations of secular perturbation by various methods and investigating the influence of variable masses 5) Obtaining trends in the change of analogues of Kepler elements 6) To conduct a comparative analysis of the problem of three bodies with a stable state of mass.

	7) To conduct a comparative analysis of the calculation of three bodies with variable masses of three bodies with constant masses.
Expected and achieved results	**Explanatory note** 1. Obtaining a solution to the two-planet problem of secular perturbation of the differential equations of the problem of three bodies whose masses change anisotropically at different rates. Review on the topic of the problem. Teaching one or more disciplines in each semester. 2. Comparison and obtaining graphs of differences of isotropically varying results of the problem of three bodies with variable masses. Obtaining graphs using the Wolfram Mathematica program. Completion of the dissertation work. 3. Research of the dissertation problem on the Newtonian type of perturbed motion in which reactive forces are clearly visible. Prepare and submit an article to the journals included in the Web of Science or Scopus database. 4. Preliminary defense of the dissertation work at the department, faculty, seminar. Teaching one or more subjects per semester. 5. Analysis of future scientific papers with a foreign consultant. Equations of perturbed motion in the form of Newton's equation. Participation in the seminar. 6. Analysis of the results of solving the problem of secular perturbation of Newton's equations for real objects. Prepare and submit an article to journals included in the Web of Science or Scopus database. 7. New scientific works. Analysis of the results obtained in the form of Newton's equations in the form of secular perturbation equations. Teaching one or more subjects per semester. 8. ICCMMS 2024: 18. International Conference on Computer Mathematics and Mathematical Sciences. 08-09 July 2024. in Prague, Czech Republic. Prepare articles and participate online 9. Write and send a monograph to Kazakh publishing houses with a domestic scientific consultant. 10. Analysis of the results of the work performed in the project. Writing and preparation of the final report.
List of publications with links to them	• ***Published an article in the journal included in the SCOPUS database:*** 1. Zh.U. Imanova, A.N., Prokopenya, M.Dzh. Minglibayev, Modelling the Evolution of the Two-Planetary Three-Body System of Variable Masses, Mathematical Modelling and Analysis 2023, 28(4), 636–652 (Q2) https://www.scopus.com/authid/detail.uri?authorId=57195450346 • ***Published abstracts in the proceedings of international conferences:*** 1. Minglibayev M.J., Prokopenya A.N., Imanova Zh.U., Evolutionary equations of the two-planet three-body problem with variable masses, Proceedings of the international Scientific and Practical Conference

	«Priorities of mechanics and automatic control theory in development of space technique and technology» dedicated to the 75th anniversary of the professor, academician of NAS RK and NEA Rok Moldabekov Meirbek September 14,2022, Almaty 36-41p. 2. Minglibayev M., Prokopenya A., Imanova Zh.U. Investigation of a two-planetary problem of three bodies with variable masses varying anisotropically at different rates, Applications of Computer Algebra – ACA 2023, Warsaw, Poland, July 17 – 21, 2023. P.72.