

Project name, IRN	AP08955400 – Unpredictable solutions of differential equations
Period of implementation	04.10.2020-30.09.2021
Project supervisor	Tleubergenova Madina Almukhanovna – Candidate of Physico-mathematical Sciences
Report	<p>In project topic, unpredictable solutions to three types of differential equations will be considered. Including:</p> <ul style="list-style-type: none"> –the problem of existence and uniqueness of unpredictable solution of non-autonomous functional differential equations and differential equations with piecewise constant argument in a complex Banach space; –a new type of oscillations, in the form of discontinuous unpredictable solutions of linear and quasi-linear impulsive systems. The investigated models will be with unpredictable perturbations. The moments of impulses of the systems under study will constitute a newly determined unpredictable discrete set. Theoretical results on the existence, uniqueness, and stability of discontinuous unpredictable solutions of linear and quasi-linear impulsive differential equations; –the existence of unpredictable solutions of partial differential equations, namely the diffusion equation that describes the process of heat transfer. The equation also describes such processes as the diffusion of a substance in a solution, and the spread of a population in a certain area. <p>Application of the averaging method and theorems of Krasnoselski, Shauder fixed point theorems to prove unpredictable solutions to nonlinear differential equations are assumed.</p>
Abstract	<p>During the previous research, M. Tleubergenova and all of the participants of research group have proved the existence and uniqueness of asymptotically stable unpredictable solutions for linear, quasi-linear ordinary differential equations. All the results are published in journals with high impact-factor and/or in journals with strong peer reviewing.</p> <p>The main feature of the project is that unpredictable oscillations are strongly connected with the type of chaos issued from the papers of H. Poincare, G. Birkhoff and other founders of the classical theory of dynamical systems. Therefore, the suggestions M. Tleubergenova, M. Akhmet and A. Zhamanshin, can affect both, development of different differential equations of many types, and the chaos theory.</p>
Purpose	The goal of the project is to develop methods for studying unpredictable solutions of functional differential equations, differential equations with piecewise constant argument of generalized type, impulsive systems, partial differential equations. Confirmation of theoretical results in the form of illustrations and numerical methods using MATLAB, Python, and MATHEMATICA programs.
Expected results	<p>The following results are expected:</p> <ul style="list-style-type: none"> • New types of oscillations of nonlinear differential equations, impulsive differential equations and partial differential equations will be created. • The dynamic properties and conditions for the existence,

	<p>uniqueness and stability of unpredictable solutions of the impulsive differential equations will be determined.</p> <ul style="list-style-type: none"> • The dynamic properties and conditions for the existence, uniqueness and stability of unpredictable solutions of the impulsive differential equations will be determined. • The dynamic properties and conditions for the existence, uniqueness and stability of unpredictable solutions of differential equations with piecewise constant argument of generalized type. • The dynamic properties and conditions for the existence, uniqueness and stability of unpredictable solutions of functional differential equations. • The dynamic properties and conditions for the existence, uniqueness and stability of unpredictable solutions of partial differential equations. • Programs and algorithms will be developed in the MATLAB environment with illustrative graphs of solutions. <p>The results will be interesting not only for mathematicians, but also for biologists, specialists in computers, social sciences, engineers in industry and electronics.</p>
<p>Research group</p>	<p><i>Project Investigator:</i> Tleubergenova Madina Almukhanovna, Candidate of Physico-mathematical Sciences, h-index h=5 (Scopus Author ID – 8952008700; ORCID - 0000-0002-5572-2305). https://www.scopus.com/authid/detail.uri?authorId=8952008700</p> <p>Ахмет Марат – д.ф.-м.н., профессор, h-index h=23 (Scopus Author ID – 6506071803; ORCID - 0000-0002-2985-286X). https://www.scopus.com/authid/detail.uri?authorId=6506071803</p> <p>Zhamanshin Akylbek – PhD., h-index h=3 (Scopus Author ID – 57209345406; ORCID - 0000-0003-4878-4927). https://www.scopus.com/authid/detail.uri?authorId=57209345406</p> <p>Нугаева Захира Туребаевна – h-index h=2 (Scopus Author ID – 57219487297; ORCID - 0000-0003-3206-3877). https://www.scopus.com/authid/detail.uri?authorId=57219487297</p>
<p>List of publications in scientific journals</p>	<p>List of publications in domestic journals, including those recommended by the CCSES MES RK:</p> <p>Article</p> <p>1. Akhmet M., Tleubergenova M., Nugayeva Z. An impulsive system with unpredictable oscillations // Kazakh Mathematical Journal. 21(1), 20121, pp. 25–37. http://www.math.kz/media/journal/journal2021-07-3073463.pdf</p> <p>Monograph</p> <p>1. Тлеубергенова М.А. Асимптотические свойства систем дифференциальных уравнений. Актобе, 2020. -114 с.</p> <p>List of publications in peer-reviewed foreign scientific journals, including those indexed by the Web of Science or Scopus databases, including non-zero impact factors:</p>

1. Akhmet M., Arugaslan Çinçin D., Tleubergenova M., Nugayeva Z. Unpredictable oscillations for Hopfield-type neural networks with delayed and advanced arguments // Mathematics. – 2021. - vol. 9(5). - № 571. (Q1, 80%, IF 2.165)
<https://doi.org/10.3390/math9050571>
2. Akhmet M., Tleubergenova M., Nugayeva Z. Unpredictable oscillations of impulsive neural networks with Hopfield structure // Trends in Data Engineering Methods for Intelligent Systems. Proceedings of the International Conference on Artificial Intelligence and Applied Mathematics in Engineering (ICAIAME 2020). – 2021. – №76. – P. 1–18. (входит в Scopus, 41%, Springer) https://doi.org/10.1007/978-3-030-79357-9_59
3. Akhmet M., Tleubergenova M., Nugayeva Z. Unpredictable solutions of Impulsive Quasi-Linear Systems // Discontinuity, Nonlinearity, and Complexity. – 2022. 1(11), – P.73– 89. (19%, IF 0.39). DOI:5890/DNC.2022.03.006