

<b>Project name, IRN</b>	<b>AP09258737 – Theory of unpredictable oscillations</b>
<b>Period of implementation</b>	01.03.2021-31.12.2023
<b>Project supervisor</b>	Tleubergenova Madina Almukhanovna – Candidate of Physico-mathematical Sciences
<b>Report</b>	<i>Brief description of the project idea.</i> Investigation of unbounded unpredictable functions and weakly unpredictable functions. The proof of limit theorems, Dini's theorem for sequences of unpredictable functions and the mean value theorem for unpredictable functions on group. Confirmation of the Poincare chaos through the sequential test and comparison with conservative types of chaos.
<b>Abstract</b>	Oscillations are functions, which of indisputable importance for applications. This is why they are in the focus not only of applied mathematics, theory of differential equations, first of all, but also attracts strong attention of mathematicians in theory of functions, theory of operators and, even group theory. This is true for periodic oscillations and almost periodic motions, primarily. Theory of almost periodic and periodic functions is the well-developed research, which consider problems of integration, Fourier series, generalized functions, special functional spaces, periodic and almost periodic operators and functions on groups. This all, are needed first of all for applications connected to mechanics, physics, astronomy, quantum physics and biology. Another modern line of oscillations theory is related to chaotic dynamics, where oscillations are not personalized in their behavior, and are described in their collective motions. Chaos research considers first of all mutual relations of coupled motions and also relations of a special single oscillation to all others, involved in the dynamics. For this reason, despite of more than half-century history of the chaos theory, individual characteristics of chaotic oscillations have been out of interests of mathematicians. The main and unique reason for this has been the fact that chaotic dynamics is considered as a collective one, despite irregularity in behavior is an individual property. The state of deals was changed sharply with the introduction of a new type of oscillations, unpredictable functions. This was done in 2017-2019 years, in papers of M. Tleubergenova, M. Akhmet, and their colleagues.
<b>Purpose</b>	The goal of the project is foundation and development of the basics of the theory of unpredictable functions by considering, needs of the theory of differential equations as well as chaos. To make the research more strongly connected with applications, beside the functional, theoretical, investigations, we shall develop the numerical methods of analysis, which are confirmed by simulations and MATLAB programs.
<b>Expected results</b>	<ul style="list-style-type: none"> <li>• The definition and theorems on basic properties of unbounded unpredictable functions.</li> <li>• Limit theorems for sequences of unpredictable functions. The analog of the Dini's theorem for sequences of unpredictable functions.</li> <li>• The mean value theorem.</li> <li>• Conditions for expansion of unpredictable functions in trigonometric series.</li> <li>• The definition of unpredictable functions on abstract groups,</li> </ul>

	<p>unpredictable functions from a group into a Banach space. The criterion of total-boundedness for families of functions.</p> <ul style="list-style-type: none"> <li>• The properties of weakly unpredictable functions: weak unpredictability, weak continuity, boundedness and closeness of the set of weakly unpredictable functions.</li> <li>• The Poincaré chaos identification in various models by the sequential test.</li> <li>• Relations between Poincaré chaos and chaos of Devaney and Li-Yorke types.</li> <li>• Programs and algorithms will be developed in the MATLAB environment with illustrative graphs of solutions.</li> </ul>
<p><b>Research group</b></p>	<p><i>Project Investigator:</i> Tleubergenova Madina Almukhanovna, c.ph.-m.s., h-index h=5 (Scopus Author ID – 8952008700; ORCID - 0000-0002-5572-2305).  <a href="https://www.scopus.com/authid/detail.uri?authorId=8952008700">https://www.scopus.com/authid/detail.uri?authorId=8952008700</a></p> <p>Akhmet Marat – d.ph.-m.s., professor, h-index h=23 (Scopus Author ID – 6506071803; ORCID -0000-0002-2985-286X).  <a href="https://www.scopus.com/authid/detail.uri?authorId=6506071803">https://www.scopus.com/authid/detail.uri?authorId=6506071803</a></p> <p>Seilova Roza, c.ph.-m.s., h-index h=2 (Author ID в Scopus – 8906569600).  <a href="https://www.scopus.com/authid/detail.uri?authorId=8906569600">https://www.scopus.com/authid/detail.uri?authorId=8906569600</a></p> <p>Zhamanshin Akylbek – PhD., h-index h=3 (Scopus Author ID – 57209345406; ORCID - 0000-0003-4878-4927).  <a href="https://www.scopus.com/authid/detail.uri?authorId=57209345406">https://www.scopus.com/authid/detail.uri?authorId=57209345406</a></p> <p>Nugayeva Zakhira PhD student, master, h-index h=2 (Author ID в Scopus – 57219487297; Researcher ID - AAP-4906-2021; ORCID 0000-0003-3206-3877)  <a href="https://www.scopus.com/authid/detail.uri?authorId=57219487297">https://www.scopus.com/authid/detail.uri?authorId=57219487297</a></p> <p>Izgarina Gulzhanat – master, senior teacher</p> <p>Isabergenova Zhuldyz – master</p>
<p><b>List of publications in scientific journals</b></p>	<p>List of publications in domestic journals:</p> <ol style="list-style-type: none"> <li>1. Akhmet M.U., Tleubergenova M., Nugayeva Z. An impulsive system with unpredictable oscillations // Kazakh Mathematical Journal. 21(1), 20121, pp. 25–37.</li> </ol> <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> <ol style="list-style-type: none"> <li>1 Akhmet M.U., Aruğaslan Çinçin D., Tleubergenova M.A., Nugayeva Z.T. Unpredictable Oscillations for Hopfield-Type Neural Networks with Delayed and Advanced Arguments // Mathematics. 2021. 9(10), 571. <a href="https://doi.org/10.3390/math9050571">https://doi.org/10.3390/math9050571</a> (квартиль в базе Web of Science Q1, процентиль в базе Scopus 80, IF 2.258).</li> <li>2 Akhmet M.U., Tleubergenova M.A., Nugayeva Z.T. Unpredictable Oscillations of Impulsive Neural Networks with Hopfield Structure //</li> </ol>

	<p>Trends in Data Engineering Methods for Intelligent Systems. Proceedings of the International Conference on Artificial Intelligence and Applied Mathematics in Engineering (ICAIAME 2020)). – 2021. – vol.76. – P. 625–642. <a href="https://doi.org/10.1007/978-3-030-79357-9_59">https://doi.org/10.1007/978-3-030-79357-9_59</a> (процентиль в базе Scopus 41, Springer).</p>
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