

*P. A. Biryukova, A. E. Umnov*

Moscow Institute of Physics and Technology (State University)

## On one method of analysis of solutions of optimization problems for systems of mathematical models

The aim of this paper is to present the optimization problem for the system of mathematical models of several objects. This mathematical model is created in parametrical form, which has a two-steps method of its solution. We show the method of problem solution and the method of decision sensitivity parameters of solutions using the penalty method.

**Key words:** systems of mathematical models, penalty function method, decomposition, optimization problems, sensitivity of decision, matrix of sensitivity.

*V. Zh. Sakbaev*

Moscow Institute of Physics and Technology (State University)  
Peoples' Friendship University of Russia

## On the properties of semigroups generated by random walks in infinitely dimensional space

We give the description of the set of finite additive measures on the Banach space of the sequences  $l_p$  which is invariant to the shift on an arbitrary vector of this space. The properties of the Hilbert space of complex-valued functions on the space  $l_p$  square integrable with respect to an invariant measure are investigated. We obtain a criterion of strong continuity of the semigroup of shifts on the vectors which are collinear to some nontrivial vector of the Banach space. The properties of continuous semigroups generated by random walks in the Hilbert space endowed with the invariant measures are investigated.

**Key words:** Finite additive measure, invariant measure, strongly continuous semigroup, random walks, diffusion.

*S. M. Teplyakov*

Faculty of mathematics and mechanics, Moscow State University  
Discrete mathematics, Department of innovation and high technology, MIPT

## Multicolor coloring of hypergraphs

In 1961, Erdos and Hajnal set up the problem of searching  $m(n)$  which is equal to a minimum number of edges in  $n$ -uniform hypergraph with a chromatic number more than two. Nowadays there are a lot of different estimates of this value and its generalizations. In this article, we would consider two options of the generalization of this value:  $m_k(n)$  introduced by A.M. Raygorodskiy and D.A. Shabanov and  $m_k(n, r)$  which we define in this article. We are able to find upper bounds of these values for  $k$  close to  $n/2$  in the first generalization and  $n/r$  in the second generalization. In addition, we find some properties of these bounds and prove it.

**Key words:** hypergraph, chromatic number.

*A. A. Grigoriev, P. V. Dudkin*

Moscow Institute of Physics and Technology (State University)

## Cryptographic primitives based on semidirect group products

A new class of cryptographic primitive constructions based on exponentiation in noncommutative groups is discussed. A wide class of noncommutative groups is given by the classical construction of semidirect group product. Discussing semidirect products we reveal the form of an expression for a group element power. This form leads to key generation procedure analogues to the Diffie-Hellman scheme. Two concrete key generation protocols are given. One of them is based on an extension of the multiplicative group of the simple field  $Z_p$  by some cyclic subgroup of its automorphism group. The other use is the construction of the noncommutative  $p^3$ -group as a semidirect product of cyclic groups of orders  $p^2$  and  $p$ . The complexity of attacks on a proposed key generation procedures is given.

**Key words:** cryptography, key generation, semidirect product.

*S. A. Kostyuchenko<sup>1</sup>, A. I. Dmitriev<sup>2</sup>*

<sup>1</sup>Lomonosov Moscow State University

<sup>2</sup>Moscow State University of Railway Engineering

## Information storage by nonvolatile magnetoresistive random-access memory

Nonclassical principles of data storage by nonvolatile magnetoresistive random-access memory are discussed. These principles provide the recording and storage of information in the energy limit close to Landauer estimates, where the thermodynamic aspects of information recording dominate.

**Key words:** nonvolatile random-access memory, magnetoresistive effect, nanofilms and nanowires of diluted magnetic semiconductors.

*V. A. Astapenko, A. V. Yakovets, E. Y. Ionichev*

Moscow Institute of Physics and Technology (State University)

## **Absorption of ultrashort laser pulses by hydrogen atom**

The absorption of ultrashort electromagnetic pulses on hydrogen atom in the ground state is studied theoretically. The total probability of photoabsorption is calculated for all time to the action of ultrashort pulse with allowance for excitation of an atomic electron, both in discrete and continuous energy spectrum. Two types of ultrashort pulses are considered: with carrier frequency and without it. The dependence of the probability of absorption of ultrashort pulse duration and carrier frequency is analyzed.

**Key words:** ultrashort pulse, hydrogen atom, photoabsorption.

*V. A. Astapenko<sup>1</sup>, Yu. A. Krotov<sup>2</sup>, N. N. Moroz<sup>1</sup>*

<sup>1</sup>Moscow Institute of Physics and Technology (State University)

<sup>2</sup>Joint Stock Company «Polyus Research Institute of M. F. Stelmakh»

## Elastic scattering of ultrashort laser pulses on the hydrogen atom

This work is devoted to the problem of elastic scattering of ultrashort laser pulses (ULP) on the hydrogen atom. Here we offer an expression of the scattering probability of ULP on the hydrogen atom and conduct calculations of two kinds of initial pulses: with carrier frequency and without carrier frequency. Obtained curves describing the scattering probability depending on the pulse duration are presented in the paper.

**Key words:** ultrashort laser pulses, elastic scattering, the hydrogen atom, the scattering probability.

*V. N. Golubkin<sup>1,2</sup>, G. B. Sizykh<sup>1</sup>*

<sup>1</sup>Moscow Institute of Physics and Technology (State University)

<sup>2</sup>Central Aerohydrodynamic Institute n.a. professor N. E. Zhukovskiy

## Some properties of gas flows with axial symmetry

The axisymmetric flow of an ideal gas with a twist in the circumferential direction is investigated. Streams can be nonbarotropic and vortex ones. Based on the analysis of the Euler equations, a number of previously unknown qualitative properties of such flows are obtained. In particular, it is proved that (in the presence of the circumferential speed) the gas flow cannot be potential if at least a portion of the axis of symmetry is situated inside of the flow (not inside of a streamlined body). Also the equivalence of the two types of flows is discovered: swirling flows in the absence of external forces and not swirling flows in an axisymmetric potential field of external forces.

**Key words:** Euler's equations, axisymmetric swirling gas flow, vorticity, circulation, Munk and Prim transformation.



*V. P. Kovalev<sup>1</sup>, E. Yu. Prosviryakov<sup>2</sup>, G. B. Sizykh<sup>1</sup>*

<sup>1</sup>Moscow Institute of Physics and Technology (State University)

<sup>2</sup>Institute of Engineering Science, UB RAS, Ekaterinburg, Russia

## Obtaining examples of exact solutions of the Navier–Stokes equations for helical flows by the method of summation of velocities

Corkscrewlike flows of a viscous incompressible fluid in the potential field of external forces are considered in terms of the Navier–Stokes equations. (In this paper, flows are considered to be corkscrewlike when their vorticity is parallel to the velocity and the vorticity-to-velocity ratio is constant in space and time.) It is shown that if this ratio is equal for two corkscrew-type solutions, the vector sum of velocities for these solutions is the velocity for some corkscrew-type solution of the Navier–Stokes equations. This property is proposed to be used for obtaining new exact solutions. It is demonstrated that the vector summation yields solutions with new properties, which are not inherent to original solutions). In particular, the nonaxisymmetric exact solution can be obtained by the summation of axisymmetric Gromeka–Beltrami–Trkal solutions, i. e. solutions obtained by Trkal’s method

from Gromeka–Beltrami solutions). Exact solutions obtained by vector summation can be used to test numerical algorithms and computer programs.

**Key words:** exact solutions of the Navier–Stokes equations, helical solutions of the Navier–Stokes equations, exact solutions of the Euler equations, incompressible viscous fluid, axially symmetric flow.

*K. V. Balakin*<sup>1,2</sup>, *G. I. Lapushkin*<sup>1</sup>, *A. G. Savilova*<sup>1</sup>, *E. V. Bovina*<sup>3</sup>, *E. A. Kvashnina*<sup>1</sup>,  
*A. E. Voronkov*<sup>1</sup>, *T. M. Vasilyeva*<sup>1</sup>, *A. V. Skorenko*<sup>1</sup>

<sup>1</sup>Moscow Institute of Physics and Technology (State University)

<sup>2</sup>I.M. Sechenov First Moscow State Medical University

<sup>3</sup>Institute of Physiologically Active Compounds, Russian Academy of Sciences

## Prediction of adverse effects of antidepressants, inhibitors of serotonin and noradrenaline reuptake

In this paper, we demonstrate the ability to evaluate the potential adverse effects profile for a series of antidepressants, serotonin and noradrenaline reuptake inhibitors (SNRIs) based on their analysis *in vitro* multitarget activity data. Our approach is based on the use of computational data mining methods. At the first step, we analyze adverse effects of 10 SNRIs using the data extracted from the FDA AERS database. We also collect data for them *in vitro* multitarget activity from ChEMBL database. Calculation of pairwise similarity coefficients allow us to obtain quantitative measures of (dis)similarities of adverse effects' and multitarget activity profiles for the studied drugs. Ward's hierarchical clusterization based on the pairwise similarity coefficients reveals a clear correspondence between the two hierarchies, thus demonstrating the dependence of the adverse effects of the SNRIs on their multitarget activity profile. The results of this work pave the way for finding more general dependencies connecting spaces of the adverse effects and multitarget activity of drugs.

**Key words:** drug adverse effects, pairwise similarity coefficients, target-specific profile, clusterization.

*I. V. Gonchar*<sup>1,2</sup>, *S. A. Balashov*<sup>2</sup>, *I. A. Valiev*<sup>1</sup>, *O. A. Antonova*<sup>2</sup>,  
*A. M. Melkumyants*<sup>1,2</sup>

<sup>1</sup>Moscow Institute of Physics and Technology (State University)

<sup>2</sup>Russian Cardiology Research Center

## Role of endothelial glycocalyx in the mechanogenic regulation of arterial tone

The role of endothelial glycocalyx in the shear-induced control of arterial tone is investigated on common carotid and femoral arteries of anesthetized rabbits. It is shown that glycocalyx disruption using hyaluronidase or heparinase considerably hampers or eliminates the ability of these vessels to dilate in response to the increased flow rate, whereas their response to acetylcholine remains practically the same as in the arteries with intact glycocalyx. Besides, in experiments using the culture of human umbilical vein endothelial cells, we show that the disruption of glycocalyx leads to a complete loss of the cell's ability to orient in parallel to the flow. Both results evidence the key role of endothelial glycocalyx in the shear-induced control of arterial tone.

**Key words:** endothelial glycocalyx, endothelium-dependent vasodilation, flow induced dilation, shear stress, blood flow, mechanoreception, circulatory regulation.