

Ministry of Education and Science
Russian Federation
National Research Nuclear University MEPhI

6th International conference
“Problems of Mathematical Physics
and Mathematical Modelling”

Book of abstracts
(Moscow, NRNU MEPhI, 25–27 May 2017)

Moscow, Russia

УДК 51(06)+53(06)
ББК 22.1г+22.3г
I73

6th International conference “Problems of Mathematical Physics and Mathematical Modelling”: Books of abstracts (Moscow, NRNU MEPhI, 25–27 May). / M.B. Kochanov.
M.: Moscow, 2017. — 221 p.
ISBN 978-5-7262-2378-0

The book contains abstracts of 6th International conference “Problems of Mathematical Physics and Mathematical Modelling”

The contributions are reproduced directly from the originals
presented by the authors

УДК 51(06)+53(06)
ББК 22.1г+22.3г

ISBN 978-5-7262-2378-0

© *National Research Nuclear University MEPhI, 2017*

Decision on publication 22.05.2017. Format 60x84 1/8.
Quires 27,75. Circulation 120. Order №76.

National Research Nuclear University MEPhI
Printing house NRNU MEPhI
115409, Moscow, Kashirskoe shosse, 31

Co-chairs

V.V. Kozlov, Member of the Russian Academy of Science, Russia

N.A. Kudryshov, Head of department of Applied Mathematics NRNU MEPhI, Russia

O.V. Nagornov, Head of department of Higher Mathematics of NRNU MEPhI, Russia

Program committee

V.V. Kozlov, Member of the Russian Academy of Science, Russia

N.A. Kudryshov, Head of department of Applied Mathematics NRNU MEPhI, Russia

O.V. Nagornov, Head of department of Pure Mathematics of NRNU MEPhI, Russia

N. Pogorelov, University of Alabama in Huntsville, USA

A.V. Aksenov, Lomonosov Moscow State University, Russia

S.Yu. Misyurin, Director of Institute of Cyber Intelligence Systems NRNU MEPhI, Russia

V. Arakelyan, Institut National des Sciences Appliquées, France

P. Chardonnet, University of Savoie, France

Y. Efendiev, Director of Institute for Scientific Computation, Texas A&M University, USA

S.A. Kaschenko, Yaroslavl State University, Russia

A.V. Kryanev, NRNU MEPhI, Russia

R. Lazarov, Texas A&M University, USA

A.D. Polyinin, IPMech RAS, Russia

O.I. Vinogradova, Lomonosov Moscow State University, Russia

R. Conte, Condensed Matter Laboratory, CEA Saclay, France

P. Bedrikovetsky, University of Adelaide, Australia

<i>Avvakumov A.V., Strizhov V.F., Vabishchevich P.N., Vasilev A.O.</i> Modelling dynamic processes in a nuclear reactor by state change modal method.....	112
<i>Beskrovnaya A.A., Savyolova T.I.</i> Calculation of pole figures by functions on S^2 in R^3 that are projections from the canonical normal distribution on $SO(3)$	114
<i>Brykalov S.M., Kryanev A.V.</i> Mathematical model comparing of the multi-level economics systems.....	116
<i>Bychkov P.S., Saifutdinov I.N.</i> Holographic Interferometry of Thin-walled Structure Distortion during the Stereolithography Process.	118
<i>Derenovskaya O.Y., Ivanov V.V., Ogorodnikova D.S.</i> $J/\psi \rightarrow e^+e^-$ decays reconstruction for 10 AGeV Au+Au collisions in the CBM experiment.....	120
<i>Divakov D.V., Malykh M.D., Sevastianov L.A., Nikolaev N.E.</i> Modeling the propagation of polarized light in a thin-film waveguide lens	122
<i>Druzhinina O.V., Sevastianov L.A., Vasilyev S.A., Vassilyeva D.G.</i> Lyapunov stability analysis for the generalized Kapitza pendulum	123
<i>Eferina E.G., Kulyabov D.S.</i> Implementation of diagram technique for statistical systems in Sympy	125
<i>Egorov A.A.</i> Influence of fluctuations of local orientation of nematic liquid crystal molecules on the coefficient of damping of waveguide modes	128
<i>Filatov S.V., Savyolova T.I.</i> About normal distribution on $SO(3)$ group in texture analysis.....	130
<i>Gubin S.A., Maklashova I.V., Mel'nikov I.N.</i> The molecular dynamics method as the technique for properties evaluation of shock-compressed copper.....	131
<i>Karimov A.R., Dementev A.A.</i> Collisionless relaxation of non-neutral Maxwellian plasmas	133
<i>Korotkov E.V.</i> Developing of mathematical approach for multi alignment of promoter sites and regions of splicing.....	134
<i>Kudinov A.V., Bogdanova Y.A., Gubin S.A.</i> Molecular dynamics simulation of thermodynamical properties of methane	136
<i>Kuksenok I.S.</i> Divergence of the wing in the supersonic gas flow and some equilibrium states	138
<i>Kukudzhanov K.V., Levitin A.L.</i> The healing of damage of metal under treatment high-energy pulsed electromagnetic field.	140
<i>Kulyabov D.S., Gevorkyan M.N., Demidova A.V., Korolkova A.V., Sevastianov L.A.</i> The construction of the SDE for modeling wind speed for wind power plants.....	141
<i>Makin V.S., Makin R.S.</i> Nonlinear mathematical model for spatial periods of micro- and nanogratings formation in framework of universal polariton model of laser-induced condensed matter damage.....	143
<i>Malykh M.D., Sevastianov L.A., Tyutyunnik A., Nikolaev N.E.</i> On the representation of Maxwell's equations in closed waveguides by the help of Helmholtz equations.....	145
<i>Manzhirrov A.V., Kazakov K.E.</i> Axisymmetric contact problem for a rigid punch and a coated foundation with rough surfaces.....	147
<i>Misyurin S.Y., Kreinin G.V.</i> Coordinated interaction of two hydraulic cylinders when moving large-sized objects	149
<i>Misyurin S.Y., Kreinin G.V.</i> Selecting the parameters of the power channel of the automated drive	150
<i>Misyurin S.Y., Kreinin G.V., Nelyubin A.P.</i> Dynamic design and control of a high-speed pneumatic jet actuator.....	151
<i>Misyurin S.Y., Nelyubin A.P.</i> Multicriteria adaptation principle on example of groups of mobile robots	152
<i>Murashkin E.V., Radayev Y.N.</i> A Thermomechanical Constitutive Law in Virtue of Thermodynamic Orthogonality	153
<i>Murashkin E.V., Radayev Y.N.</i> On Wave Analytical Solution of Micropolar Elasticity for a Cylinder	155
<i>Nor A.A., Korotkov E.V.</i> New method for searching for latent periodicity in poetic texts with insertions and deletions	158
<i>Parshin D.A., Manzhirrov A.V.</i> Quasistatic problems for piecewise-continuously growing solids with integral force conditions on surfaces expanding due to additional material influx.....	159
<i>Perelmuter M.N.</i> Application of the bridged crack model for evaluation of materials self-healing	162

<i>Rashchikov V.I., Shikanov A.E.</i> Computer simulation of small size neutron generators with magnetic insulation	164
<i>Savatorova V.L., Talonov A.V., Kossovich E.L.</i> Dispersion and anisotropy of elastic waves in fractured porous media.....	166
<i>Sumskoï S.I., Sverchkov A.M., Lisanov M.V.</i> Mathematical modeling of water hammer with cavitation.....	167
<i>Suvorova Y.M., Korotkov E.V.</i> Cluster analysis of <i>S.Cerevisiae</i> nucleosome binding sites.....	170
<i>Vasilyev S.A., Kolosova I.S.</i> The Boundary Value Problem for Relativistic Schrodinger Equation.....	171
<i>Velieva T.R., Korolkova A.V., Kulybov D.S., Zaryadov I.S.</i> An approach to invistigate the regions of self-oscillations.....	174
<i>Zagrebaev A.M., Trifonenkov A.V.</i> Application of thermal-hydraulic model of RBMK-type reactor fuel channel for correction of experiment-calculated values of power and coolant flow	176

Section “Mathematical modelling”

<i>Barmenkov A.N., Barmenkov N.A.</i> About orthogonality of the single systems of special kind	179
<i>Baskakov A.V., Volkov N.P.</i> On the controllability of transition processes in problems of reactor dynamics .	180
<i>Baskakov, A.V., Volkov N.P.</i> On the controllability of the transition processes in problems of reactor dynamics	182
<i>Belendryasova E.G., Gani V.A.</i> Resonance phenomena in the φ^8 kinks scattering	184
<i>Dunin S.Z., Nagornov O.V.</i> Spontaneous evaporation of the acetone drop.....	186
<i>Ivanova T.M.</i> On the smoothing and consistency of data on pole figures	187
<i>Ivanova T.M., Serebryany V.N.</i> Simulation of complex magnesium alloy texture using the axial component fit method with central normal distributions	188
<i>Kamynin V., Bukharova T.</i> On an inverse problem for degenerate higher order parabolic equation with integral observation in time.....	189
<i>Konovalov Y.V.</i> Ice-tongue vibrations modelled by a full 3-D depth-integrated elastic model	191
<i>Kostin A.B., Sherstyukov V.B.</i> Calculation of functions of Rayleigh type for roots of the equation related to the spectral problem	193
<i>Leonov A.S., Sorokin V.N.</i> A posteriori error estimates in voice source recovery	194
<i>Lychev S.A., Koifman K.G.</i> Geometric Methods in the Theory of Structurally Inhomogeneous Bodies	196
<i>Lychev S.A., Lycheva T.N.</i> Structural Inhomogeneity in LbL Cylindrical Structures	198
<i>Murashkin E., Dats E., Klindukhov V.</i> Algorithm for Calculating the Elastic-Plastic Boundaries in the Thermal Stresses Theory Frameworks	201
<i>Nagornov O.V., Tyuflin S.A., Trifonenkov V.P.</i> Reliability of the past surface temperature reconstruction methods	203
<i>Nikitaev V.G., Nagornov O.V., Pronichev A.N., Polyakov E.V., Dmitrieva V.V.</i> Study of the noise effect on texture characteristics of blood cells using mathematical model of microscopic images of nucleus of leukocytes.	205
<i>Orlovsky D.</i> Inverse problem for the equation with n -times integrated semigroup.....	206
<i>Petrov S.V., Prostokishin V.M.</i> On Representation of Riesz-space-valued Functions by Fourier Series on Multiplicative Systems	208
<i>Rubinstein A.I.</i> On the Analog of the Bary–Stechkin Theorem of the Conjugate Functions for the Dyadic Group	210
<i>Sherstyukov V.B., Sumin E.V.</i> One method of calculating special sums composed by zeros of entire function.....	211
<i>Snezhin A.N., Vaskan I.Y., Prostokishin V.M.</i> Information-situational maps: mathematical models and application in modern training complexes	213
<i>Soloviev V.V., Tkachenko D.S.</i> On solvability for inverse problems of compact support source determination for heat equation.....	215
<i>Suchkov M.V., Trifonenkov V.P.</i> On the Localization Principle for Laplace Operator with Piecewise Constant Coefficient in Domains without Discontinuity Points.....	217

the defects (or, equivalently, for any initial damage) numerical simulations have shown that dependences of the healed and the damage from the time will not be different of order, we calculate these dependences in the regions of integration, consisting of one or few representative elements. Positions of microcracks relative to each other, their shape and distance between its does not affect on the dependences of the healed and the damage from the time under the treatment of current pulse. These changes are affected by the value of initial damage only. The dependences of the healed and the damage from the time will be practically the same for all different shapes and mutual positions of microdefects, provided that the initial damages are equal for these different mutual positions of defects. Based on the simulation results, the approximate piecewise-linear dependences of healed and damage from time and the initial damage are obtained. It follows from the dependencies that up to the certain moment in time all the microcracks in the material (regardless the initial damage) does not heal and damage of the material is not changed under the current. After this moment in time it will start the process healing of microcracks. Thus, under the action of the current the damage of material is decreased over time at the constant rate (independent of the initial damage) over time, while the healed is increased over time at a rate inversely proportional to the initial damage of the material. The work was supported by the Russian Foundation for Basic Research (Grant No. 15-08-08693).

The construction of the SDE for modeling wind speed for wind power plants

D.S. Kulyabov^{1,2,a)} , M.N. Gevorkyan^{1,b)} , A.V. Demidova^{1,c)} , A.V. Korolkova^{1,d)} , L.A. Sevastianov^{1,3,e)}

¹*Peoples' Friendship University of Russia (RUDN University)*

6 Miklukho-Maklaya St, Moscow, 117198, Russian Federation

²*Laboratory of Information Technologies Joint Institute for Nuclear Research*

6 Joliot-Curie, Dubna, Moscow region, 141980, Russia

³*Bogoliubov Laboratory of Theoretical Physics Joint Institute for Nuclear Research*

6 Joliot-Curie, Dubna, Moscow region, 141980, Russia

This work considers the problem of modeling evolution of wind speed in the area of of wind turbines farm. As the statistical data we use the table of turbine performance, wind speed and direction from the wind farm on the territory of Republic of Poland. We use Weibull distribution to approximate wind speed. Parameters of Weibull distribution were calculated by the method of maximum likelihood. We also have calculated the autocorrelation coefficient for the entire data range and have proved the local exponential decrease nature. After that, we built a stochastic differential equation and solved it with stochastic numerical methods.

The work is partially supported by RFBR grants No's 15-07-08795 and 16-07-00556. Also the publication was financially supported by the Ministry of Education and Science of the Russian Federation (the Agreement No 02.A03.21.0008).

^{a)}Email: kulyabov_ds@rudn.university

^{b)}Email: gevorkyan_mn@rudn.university

^{c)}Email: demidova_av@rudn.university

^{d)}Email: korolkova_av@rudn.university

^{e)}Email: sevastianov_la@rudn.university

Introduction

Popularity of alternative renewable energy sources increases constantly. One type of such sources is the farm of wind turbines. Its main disadvantage is the strong dependence on metrological conditions, particularly wind speed. Therefore, the modeling of the evolution of the wind speed in time is essential for predicting the efficiency and profitability of wind turbines.

In this paper we build a stochastic model based on data obtained from one of the wind farms located on the territory of the Republic of Poland. We used model building mythology from articles [1, 2]. Also we use Python with NumPy, SciPy and [3], Matplotlib [4] libraries with interactive shell [5].

Approximating distributions

In the first phase of work on the basis of statistical data was constructed frequency histogram. From visual analysis of that histogram we fined out the possibility to use distributions with heavy tails for the approximation of the available data. We used method of maximum likelihood to compute the parameters of the four distributions: lognormal, gamma, Weibull (three parameter each) and beta (four parameter). For the analysis of the results we plotted frequency histogram and distributions PDF function graph on the same axis. Also we plotted quantile-quantile graphs for all four distributions. The analysis allowed to conclude that the optimal choice for the approximation is the Weibull distribution, which is consistent with the results known from the literature [6, 7]

SDE constraction

The method described in the article [1] implies exponential decrease of the autocorrelation coefficient $e^{-\alpha\tau}$, where α — some coefficient, and τ — autocorrelation lag. The coefficient α plays a significant role bocouse it is included as a parameter in the resulting equation.

The calculation of the autocorrelation coefficient based on the data available to us and plotting its values in graphical form allows to verify the exponential character of decrease, at least for the initial values of the lag. To calculate α coefficient we use least squares methods.

As soon as we know parameters of Weibull distribution and the coefficient α we are able to construct stochastic differential equation, whose solution is a stochastic process, approximately the evolution of wind speed changes in time and in each moment of time has a Weibull distribution.

To solve stochastic differential equation we use stochastic numerical Runge-Kutta methods, implemented and described in our earlier [8, 9] paper. The nature of the resulting numerical solution reflects a qualitative picture of the available statistical data. Numerical solution reflects the properties of empirical data — such as sharp jumps to extreme levels with the further sharp return to the averages values.

Conclusion

As a further direction of research is planned to verify the model built based on statistical data of larger size, which we plan to get in future. We also planning to include in the model along with the wind speed also the performance of the wind turbine.

References

- [1] Miñano Rafael Zárate, Milano Federico. Construction of SDE-based wind speed models with exponential autocorrelation. — 2015. — arXiv:1511.02345.
- [2] Zárate-Miñano R., Mele F. M., Milano F. SDE-based wind speed models with Weibull distribution and exponential autocorrelation // 2016 IEEE Power and Energy Society General Meeting (PESGM). — 2016. — July. — P. 1–5.
- [3] Jones Eric, Oliphant Travis, Peterson Pearu et al. SciPy: Open source scientific tools for Python. — 2001–. — [Online; accessed 19.01.2017]. Access mode: <http://www.scipy.org/>.
- [4] Droettboom Michael, Caswell Thomas A, Hunter John et al. matplotlib/matplotlib: v2.0.0. — 2017. — Jan. — Access mode: <https://doi.org/10.5281/zenodo.248351>.
- [5] Project Jupyter home. — 2017. — [Online; accessed 19.01.2017]. Access mode: <https://jupyter.org>.
- [6] The Weibull distribution function and wind power statistics / G. J. Bowden, P. R. Barker, V. O. Shestopal, J. W. Twidell // Wind Engineering. — 1983. — Vol. 7. — P. 85–98. — Provided by the SAO/NASA Astrophysics Data System. Access mode: <http://adsabs.harvard.edu/abs/1983WiEng...7...85B>.
- [7] Norman L. Johnson Samuel Kotz N. Balakrishnan. Continuous Univariate Distributions, Vol. 1 (Wiley Series in Probability and Statistics). — Wiley-Interscience, 1994. — Vol. 1 of Wiley Series in Probability and Statistics. — ISBN: 0471584959, 9780471584957.
- [8] Stochastic Runge–Kutta Software Package for Stochastic Differential Equations / M. N. Gevorkyan, T. R. Velieva, A. V. Korolkova, D. S. Kulyabov, L. A. Sevastyanov. // Dependability Engineering and Complex Systems. — Springer International Publishing, 2016. — Vol. 470. — P. 169–179. — 1606.06604.
- [9] Eferina, E.G., Korolkova, A.V., Gevorkyan, M.N., Kulyabov, D.S., Sevastyanov, L.A.: One-step stochastic processes simulation software package, bulletin of peoples' friendship University of Russia. Math. Inf. Sci. Phys. (3), 46–59 (2014)

Nonlinear mathematical model for spatial periods of micro- and nanogratings formation in framework of universal polariton model of laser-induced condensed matter damage

V.S. Makin^{1,a)}, R.S. Makin^{2,b)}

¹*NII OEP*

²*NRNU MEPhI*

^{a)}Email: makin@sbor.net

^{b)}Email: rmak@sai-net.ru