Alexey Cherezov

Curriculum Vitae

Education

2008–2011 **PhD, Nuclear Engineering**, *Moscow Engineering Physics Institute (MEPhI)*, Moscow, Specialty no. 051318 Mathematics and Computer Science.

2002–2008 **BSc/MSc, Nuclear Engineering**, *Moscow Engineering Physics Institute (MEPhI)*, Specialty no. 140305 Theoretical Physics and Numerical Methods for Modeling Nuclear Reactor Cores, GPA 3.55.

PhD Thesis

Title *Method of Spectral Projection for Nuclear Reactor Safety Analysis*

Supervisors Professor Nikolai V. Shchukin & Associate Professor Andrey Semenov

Description There are two main types of nuclear reactors used in Russian Federation: High Power Channel-Type Reactor ("RBMK") and Water-Water Energetic Reactor ("WWER"). The power management of "RBMK" reactors is carried out by control rods and coolant flow. The control rod worth is evaluated by signals from the in-core neutron detectors. However, in practice, signal processing algorithms lead to systematic errors. Therefore, a new method has been developed and verified for the control rod worth measurements on the "RBMK" critical facility. The method relies on the spectrum decomposition of the neutron diffusion operator, reconstruction of the time-dependent assembly-wise power distribution, and analysis of the spectral projection of the signal. It has been shown that the method allows to significantly improve the accuracy of control rod worth measurements.

Master Thesis

Title *Development of the Robust Time-Integration Schemes for the Spatial Neutron Kinetics Module of the Neutron Diffusion Code "ROSA"*

Supervisors Professor Nikolai V. Shchukin & Associate Professor Andrey Semenov

1 Gwanak-ro, Daehak-dong, Gwanak-gu, Seoul – Republic of Korea, 08826
+82 (10) 8788 6485 • alcherezov.one@gmail.com
Skype: alexey.cherezov

Description The transient analysis of the nuclear reactor cores involves a simulation of coupled physical phenomena having different characteristic times. As a result, the initial value problem for the underlying PDEs is stiff and the higher-order explicit time-marching schemes (such as Runge-Kutta, Adams-Moulton, Adams-Bashforth, etc) become inefficient due to the instabilities occurring at large time steps. The fully implicit, multi-step time-integration algorithm was developed based on Backward Differential Formula (BDF). The new method provides the $A(\alpha)$-stability and allows the integration of stiff problems with large time steps keeping a small local error. The algorithm was imported to the code "ROSA" developed for the 3D analysis of the neutron field transients using the multi-group diffusion approximation with the finite-difference discretization in space. The implementation was validated through the series of benchmark problems.

Experience

2016–Present **Post-doctoral researcher**, Seoul National University, Seoul.

- Development of the reduced basis element method. The recent trend in nuclear reactor analyses is multi-physics simulation of the reactor cores with a pin-level resolution. In many practical applications, such high-fidelity simulations need to be performed repeatedly and require prohibitive computational costs. To decrease the computational expenses, a new approach was proposed based on the discontinuous Galerkin finite element and proper orthogonal decomposition methods. In this approach the polynomial basis of finite element is replaced by preliminary calculated *ad-hoc* basis functions. The basis is optimum for representative set of snapshots, therefore it allows to keep the required accuracy of global solution. The new basis functions are piece-wise polynomials, which could not be patched continuously on cell interfaces. To keep the neutron balance, the non-conformal finite element method is employed, in which a solution is seeking in a broken space of functions having discontinuity on cell interfaces with their first derivatives. This approach has been applied for the diffusion approximation and for the transport Boltzmann equation with SP_3 and S_N angle discretization.
- Development of the xenon-samarium transient simulation algorithm. The algorithm was implemented in the structure of the three-dimensional nodal core simulator "RENUS".
- Teaching the one-month course "Introduction to Numerical Methods for Nuclear Reactor Simulation".

2011–2016 **Engineer Team Lead**, Experimental Research and Design Association "Training Simulators", Moscow.

- Development and improvement of the neutron cross-section libraries for the training simulators of the reactor facility "VVER-1000". In particular, the calculation of diffusion coefficients for the axial reflectors was significantly improved in terms of accuracy and performance.
- Implementation of the time integration schemes for the nodal diffusion code "SKETCH-N". The family of integration schemes is based on application of the backward differential formulas and designed for the improvement of simulator performance.
- Development of the adjoint neutron flux calculation algorithm. The algorithm was developed for acceleration of the fast reactor simulations based on the multi-group diffusion approach with discontinuity factors.
- Coupling of the in-house thermal-hydraulic code with the multi-physics reactor simulation platform "ENICAD".

2011–2016 **Engineer**, Moscow Engineering Physics Institute (MEPhI), Moscow.
- Development of diagnostic software for the nuclear power plants "RBMK-1000".
- Development of the neutron, multi-group, diffusion code "ROSA". The code is primarily used for optimization of the transport reactor cores.
- Supervising the course and diploma works.
- Teaching the class "Numerical Methods for Nuclear Reactor Simulations".

Computer skills

Languages: C++, Fortran, Python, MatLab, Wolfram Mathematica

Libraries: PETSc, SLEPc, FEniCS, deal.II, SciKit-Learn

HPC: MPI, ZeroMQ

Other: LaTeX, Linux, GIT, SVN, MCNP, etc

Conferences

2017 International Conference on Mathematics and Computation Methods Applied to Nuclear Science and Engineering "M&C-2017", Jeju, Korea. Title of presentation:
- *"A Reduced-Basis Element Method for Pin-by-Pin Reactor Core Calculations"*

2015 Seminar on Neutron-Physical Problems of Nuclear Energy "Neutronik-2015", Obninsk, Russian Federation. Title of presentation:
- *"Uncertainty of the Neutron Flux in Critical Reactor Core"*
- *"Using of Backward-Differential Formula for Neutron Kinetic Equations"*

2014 International Telecommunications Conference of Students and Young Scientists "MEPhI-2014", Moscow. Title of presentation:
- *"First Order Perturbation Theory for the Fast Lead Reactor Uncertainty Analysis"*
- *"About the Convergence of the Fission Source Iterations with Stochastic Noise"*
- *"Reconstruction of the "RBMK" Critical Stand Power Field using Least-Square Method"*
- *"Development of the BR-1200 Reactor Core Model using SKETCH-N Neutron Code"*

Seminar on the Physics of Nuclear Reactors "Volga-2014", Moscow, Russian Federation. Title of presentation:
- *"Dynamic Reactivity Effect on Neutron Power"*

2013 Seminar on Neutron-Physical Problems of Nuclear Energy "Neutronik-2013", Obninsk, Russian Federation. Title of presentation:
- *"Analysis of Neutron Flux Covariance Matrix in Multigroup Diffusion Approximation"*

2012 Seminar on Neutron-Physical Problems of Nuclear Energy "Neutronik-2012", Obninsk, Russian Federation. Title of presentation:
- *"Application of the GPU acceleration algorithms for Monte-Carlo neutron calculation code GETERA"*

Awards

2013 Award for the best presentation on the conference "Neutronik-2013"

2011 Award for the best presentation on the conference "MEPhI-2011"

2009 1-year grant of Federal Target Program "Scientific and Teaching Staff" for the work titled "Development of Numerical Methods for Advanced Fast Reactors Simulation"

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Publications

Refereed Journal Articles

1. Cherezov A., Sanchez R., Joo H.G. A Reduced-Basis Element Method for Pin-by-Pin Reactor Core Calculations in Diffusion and SP_3 Approximations. Annals of Nuclear Energy, 2018, vol. 116, pp. 195-209
2. Zimin V., Cherezov A. Application of Backward Differentiation Formulas to Neutron Kinetics Problems. Physics of Atomic Nuclei, 2017, Vol. 80, No. 8, pp. 1377-1386
3. Cherezov A. Analysis of the Correlation Function of the Neutron Field in a Critical Reactor Taking into Account of the Neutron Intensity Regulation System. Atomic Energy, 2016, vol. 120, no.2, pp. 100-104
4. Cherezov A., Shchukin N. et al. Computational Validation of the Spectral Projection Method Using Models of the RBMK Critical Stand. Atomic Energy, 2016, vol. 119, Issue. 4, pp. 234-241
5. Glazkov V., Gruzdov F., Druzhaev A., Semenov A., Solovev D., Cherezov A., Shchukin N., Morozov A. RBMK-1000 Computational-Measurement Diagnostics System. Atomic Energy, 2016, vol. 119, Issue. 4, pp. 242-246
6. Cherezov A., Semenov A. et al. Calculation of the Covariation Matrix of the Neutron Flux Density in the Multigroup Diffusion Model of a Subcritical Reactor. Atomic Energy, 2015, vol. 117, no. 5, pp. 299-306
7. Cherezov A., Shchukin N., Semyonov A., Solovyov D. Using the Procedure of Spectral Projection for Reactivity Determination in Physically Large Nuclear Reactors. Physics of Atomic Nuclei, 2011, Vol. 74, Num. 14, pp. 1900-1907

Refereed Full Conference Papers

1. Cherezov A., Joo H.G. International Conference on Mathematics and Computation Methods Applied to Nuclear Science and Engineering "M&C-2017", Jeju, Republic of Korea
2. Cherezov A.L., Shchukin N.V. Interpretation of Experimental Data on Safety Parameters from Standpoint of Mathematical Nuclear Reactor Theory. International Conference on the Physics of Reactors 2012, PHYSOR 2012: Advances in Reactor Physics 2012, pp. 3293-3301

Other publications

1. Ivanov I.E, Shchukin N.V., Bychkov S.A., Druzinin V.E., Cherezov A.L. Application of the GPU acceleration algorithms for Monte-Carlo neutron calculation code GETERA. Nuclear Physics and Engineering, Vol. 3, issue 2, pp. 188-193
2. Deev V.I., Shchukin N.V., Cherezov A.L. Basis of ships' nuclear power plant calculations. Textbook, 2012, MEPhI, p. 256
3. Shchukin N., Cherezov A. Determination of the Dynamic Characteristics of a Nuclear Reactor Using the Spectral Projection. Nuclear Physics and Engineering, Vol. 3, issue 1, pp. 20-27

Languages

Russian

English

Research Interests

- Neutron transport equation
- Reduced order models
- Time integration methods
- Regression analysis
- Linear system solvers
- Finite element method
- Domain decomposition
- Perturbation theory

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References

Han Gyu Joo — Professor of Seoul National University, Department of Nuclear Engineering, Reactor Physics Laboratory, joohan@snu.ac.kr

Richard Sanchez — Visiting professor of Seoul National University, Former research director of the French Alternative Energies and Atomic Energy Commission (CEA), richard.abuli@protonmail.com

Nikolai Shchukin — Professor of the department of Theoretical and Experimental Physics of Nuclear Reactors, NRNU MEPhI, nvshchukin@mephi.ru

Vyacheslav Zimin — Engineer Team Lead of ENICO "TSO", vgzimin@mail.ru

Andrey Semenov — Engineer Team Lead of ENICO "TSO", dozaand@mail.ru