

Solution of the 3D Neutron Diffusion Benchmark by FEM

A. V. Avvakumov¹, P. N. Vabishchevich², A. O. Vasilev^{3(✉)},
and V. F. Strizhov²

¹ National Research Center Kurchatov Institute, Moscow, Russia

² Nuclear Safety Institute of RAS, Moscow, Russia

³ North-Eastern Federal University, Yakutsk, Russia
haska87@gmail.com

Abstract. The objective is to analyze the neutron diffusion benchmark developed by the Atomic Energy Research community for verification of best-estimate neutronics codes. The 3D benchmark of Schulz models a VVER-1000 core in steady state. The assemblies are homogeneous, represented by given diffusion theory parameters. There are seven material compositions including four enrichments, burnable absorber, control rods and a reflector. The finite element method on tetrahedron computational grids is used to solve the three-dimensional neutron problem. The software has been developed using the engineering and scientific library FEniCS. The matrix spectral problem is solved using a scalable and flexible toolkit SLEPc. The solution accuracy of the benchmark is analyzed by condensing the computational grid and varying the degree of the finite elements.

1 Introduction

The physical processes in a nuclear reactor [1] depend on the distribution of the neutron flux, whose mathematical description is based on the neutron-transport equation [2, 3]. The equation, describing the process is of integro-differential form and the required distribution of neutrons flux depends on time, energy, spatial and angular variables. As a rule, simplified forms of the neutron transport equation are used for practical computations of nuclear reactors. The system of equations obtained by the multigroup diffusion approach is often used for reactor analysis [4, 5] and is applied in most engineering calculation codes.

The processes in a nuclear reactor are essentially non-stationary. The stationary state of neutron flux, which is related to the critical state of the reactor, is characterized by local balance between the neutron generation and absorption. This boundary state is usually described by the solution of a spectral problem (Lambda Modes problem, λ -eigenvalue problem) provided that the fundamental eigenvalue (the maximal eigenvalue) that is called k -effective of the reactor core, is equal to unity. In this case, the stationary neutron flux is a corresponding eigenfunction. Computations of k -effective of the reactor using the Lambda Modes problem are obligatory for reactor design calculations.

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Adimir dos Santos



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Fundamentals of Nuclear Engineering Brent J. Lewis, E. Nihan Onder, Andrew A. Prudil, 2017-06-19 Fundamental of Nuclear Engineering is derived from over 25 years of teaching undergraduate and graduate courses on nuclear engineering. The material has been extensively class tested and provides the most comprehensive textbook and reference on the fundamentals of nuclear engineering. It includes a broad range of important areas in the nuclear engineering field: nuclear and atomic theory, nuclear reactor physics, design, control, dynamics, safety, and thermal hydraulics; nuclear fuel engineering and health physics; radiation protection. It also includes the latest information that is missing in traditional texts such as space radiation. The aim of the book is to provide a source for upper level undergraduate and graduate students studying nuclear engineering. Nuclear Science Abstracts, 1975 **Transactions of the American Nuclear Society**, 1990

Large-Scale Scientific Computing Ivan Lirkov, Svetozar Margenov, 2018-01-10 This book constitutes the thoroughly refereed post conference proceedings of the 11th International Conference on Large Scale Scientific Computations LSSC 2017 held in Sozopol Bulgaria in June 2017. The 63 revised short papers together with 3 full papers presented were carefully reviewed and selected from 63 submissions. The conference presents results from the following topics: Hierarchical adaptive domain decomposition and local refinement methods; Robust preconditioning algorithms; Monte Carlo methods and algorithms; Numerical linear algebra; Control and optimization; Parallel algorithms and performance analysis; Large scale computations of environmental, biomedical and engineering problems. The chapter Parallel Aggregation Based on Compatible Weighted Matching for AMG is available open access under a CC BY 4.0 license. **A Nodal Method for Multigroup,**

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Table of Contents Duderstadt Manual Solution Nuclear

1. Understanding the eBook Duderstadt Manual Solution Nuclear
 - The Rise of Digital Reading Duderstadt Manual Solution Nuclear
 - Advantages of eBooks Over Traditional Books
2. Identifying Duderstadt Manual Solution Nuclear
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Duderstadt Manual Solution Nuclear
 - User-Friendly Interface
4. Exploring eBook Recommendations from Duderstadt Manual Solution Nuclear
 - Personalized Recommendations
 - Duderstadt Manual Solution Nuclear User Reviews and Ratings
 - Duderstadt Manual Solution Nuclear and Bestseller Lists
5. Accessing Duderstadt Manual Solution Nuclear Free and Paid eBooks
 - Duderstadt Manual Solution Nuclear Public Domain eBooks
 - Duderstadt Manual Solution Nuclear eBook Subscription Services

- Duderstadt Manual Solution Nuclear Budget-Friendly Options
- 6. Navigating Duderstadt Manual Solution Nuclear eBook Formats
 - ePub, PDF, MOBI, and More
 - Duderstadt Manual Solution Nuclear Compatibility with Devices
 - Duderstadt Manual Solution Nuclear Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Duderstadt Manual Solution Nuclear
 - Highlighting and Note-Taking Duderstadt Manual Solution Nuclear
 - Interactive Elements Duderstadt Manual Solution Nuclear
- 8. Staying Engaged with Duderstadt Manual Solution Nuclear
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Duderstadt Manual Solution Nuclear
- 9. Balancing eBooks and Physical Books Duderstadt Manual Solution Nuclear
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Duderstadt Manual Solution Nuclear
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Duderstadt Manual Solution Nuclear
 - Setting Reading Goals Duderstadt Manual Solution Nuclear
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Duderstadt Manual Solution Nuclear
 - Fact-Checking eBook Content of Duderstadt Manual Solution Nuclear
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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