Preface

Special issue on Fusion Neutronics

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This special issue of *Fusion Science and Technology* is devoted to new achievements reached in the field of fusion neutronics as well as its contemporary and innovative tasks. It is composed of 11 papers, thematically covering methodology and modeling advances (the first 6 papers) and achievements in computation neutronics analysis (the final 5 papers) of large fusion machines such as ITER, DEMO, ARIES, JET, NIF, and IFMIF-DONES, the geometrical and physical complexity of which are very challenging to reproduce accurately. Of course, each analysis presented in this issue is unique and requires significant computation efforts and sometimes code or interface developments. Therefore, the issue is split into parts as described. Here I introduce briefly the content of each paper.

Recently, the importance of methodological and modeling developments has increased significantly because of the ITER tokamak construction, which requires high accuracy of the neutronics results of full-scale modeling for a very detailed description of the modeled geometry. Exactly for this reason, this special issue opens with the paper titled "Algorithmic Improvements to MCNP5 for High-Resolution Fusion Neutronics Analyses" by Scott W. Mosher and Stephen C. Wilson. It should be mentioned that because of the use of high-performance computers and massively parallelized computations, one of the most demanding methods regarding computational resources, the Monte Carlo (MC) stochastic method of radiation transport with intrinsic parallelization, is widely used in fusion neutronics applications. The MC method is implemented in the MCNP5 code, and possible algorithmic improvements are described in Mosher and Wilson's paper. Algorithmic improvements to the Serpent 2 code applied for ITER neutronics analysis are described in the fifth paper of this special issue, written by Bethany Colling et al. The MCNP5 improvements are referred to as the Oak Ridge National Laboratory Transformative Neutronics (ORNL-TN) upgrade. A comparison of the performance and computer memory usage of MCNP5 and ORNL-TN on several relevant fusion neutronics models is presented in Mosher and Wilson's paper.

Multiprocessing and parallelization of the computations allow tracking every particle of radiation on the microscopic level, evaluating nuclear reactions of particle interactions with matter, and scoring the results in detectors. To get reliable results, the stochastic nature of the MC methods requires a statistically relevant population of particles in the computational model. In the case of the very complicated and physically large model described in the paper "Integration of the Full Tokamak Reference Model with the Complex Model for ITER Neutronic Analysis" by Jinan Yang et al., this can be reached by applying MC variance reduction techniques. Every paper of this special issue that presents results of MC analyses has used some variance reduction technique or validation results of previously developed methodology, as is done in the paper "Validation of the MS-CADIS Method for Full-Scale Shutdown Dose Rate Analysis" by Stephen C. Wilson et al.

As an alternative to the stochastic MC method, the use of a deterministic method in fusion neutronics is exemplified in the paper "Application of the Denovo Discrete Ordinates Radiation Transport Code to Large-Scale Fusion Neutronics" by Katherine E. Royston et al. As a general observation, discrete ordinates codes are much faster than MC codes, but they could suffer from insufficient accuracy in geometry representation and are currently used as a means of variance reduction techniques and as a complementary method to the MC method, as exemplified in the MS-CADIS method described in Wilson et al.'s paper.

Concluding the methodology part of the special issue, a paper by Yican Wu titled "Multifunctional Neutronics Calculation Methodology and Program for Nuclear Design and Radiation Safety Evaluation" presents the progress of the Institute of Nuclear Safety and Technology, Chinese Academy of Sciences, in the development of fusion neutronics methods. The paper shows the benefits of using the reference comprehensive simulation SuperMC code for nuclear design and safety evaluation of complex systems. Wu also tells us about developing the High Intensity D-T Fusion Neutron Generator, the representative experimental platform with high neutron yield on which a series of neutronics experiments has been performed, thereby providing a bridge to the next part of the issue, which focuses on fusion neutronics applications.

The applications part of the special issue begins with a second paper by Bethany R. Colling et al., titled "Comparative Study of Neutronics Analysis Techniques for Radioactive Waste Assessment," which is an interesting paper about the application of three different methods of modeling the DEMO reactor geometry for radwaste assessment. The applied methods include (1) a conventional cell-based approach, (2) a superimposed structured mesh, and (3) an unstructured mesh geometry. Colling et al. conclude that an unstructured mesh approach has the potential to be an important tool for assessing radwaste.

L. A. El-Guebaly's contribution to the special issue, a paper titled "Nuclear Assessment to Support ARIES Power Plants and Next-Step Facilities: Emerging Challenges and Lessons Learned," is a more strategic paper, with a general overview for design philosophy, nuclear assessment approach, and recent research results for the ARIES conceptual tokamak, spherical tokamak, and stellarator power plants as well as next-step facilities. The paper includes challenges and lessons learned from nuclear assessments performed over recent decades. In particular, the cost implication of uncertainties in the tritium breeding ratio prediction and the large amount of low-level waste generation are identified as important challenges facing the fusion community that should be addressed by interdisciplinary research programs.

In the paper "Calculations to Support In Situ Neutron Yield Calibrations at the Joint European Torus," Aljaž Čufar et al. describe the extensive neutronics calculations performed in support of the latest calibration experiments on JET. The presented analyses were performed using the MC method to better understand the calibration procedure, optimize the experiments, ensure personnel safety, and quantify the effects of uncharacteristic circumstances during calibration experiments.

In the paper "Simulation of the Post-Shot Radiation Environment in the National Ignition Facility," Hesham Khater et al. present calculation results for a different concept of fusion confinement. All previously mentioned papers relate to magnetic confinement fusion, but this one is about the inertial confinement fusion concept, the largest currently operating experiment for which is the NIF at Lawrence Livermore National Laboratory in the United States. The results of these detailed radiation transport simulations are presented to visualize the detailed dose rate maps for all floors inside the NIF target bay. The maps were used to estimate worker stay-out times following shots before entry is permitted into the target bay.

The final featured paper is "Global Flux Calculation for IFMIF-DONES Test Cell Using Advanced Variance Reduction Technique" by Yuefeng Qiu and Ulrich Fischer. This paper shows neutronics calculation results for the material test cell of the IFMIF-DONES employing an alternative concept to generate fusionlike neutrons on lithium targets using a powerful deuteron accelerator. The calculation procedure follows the MC method applying the advanced variance reduction tool ADVANTG developed by ORNL.

This special issue is addressed to the whole fusion community with a prerequisite knowledge of the basics —from radiation transport theories to computational methodology applications, both MC and deterministic —which can be gained from the recently published book titled *Fusion Neutronics* by Yican Wu. Information on this book is available at the end of this special issue.

I wish you good reading and hope you enjoy this special issue of *Fusion Science and Technology*!