Preface

Selected papers from the 24th Topical Meeting on the Technology of Fusion Energy

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We would like to offer our sincere thanks to the 2020 American Nuclear Society (ANS) Technology of Fusion Energy Conference (TOFE 2020) program committee for putting together an excellent program. Particular thanks go to technical program chair (TPC) and guest editor Charles Kessel for his efforts, not only in guiding an excellent program, but in working with *Fusion Science and Technology* (*FS&T*) through the publication process for this special issue. Without his work this special issue would not have been possible.

In the long history of the TOFE conference series, due to the COVID-19 pandemic restrictions, this 2020 iteration is the first to have been conducted online. It was embedded as part of the 2020 ANS Virtual Winter Meeting, held November 16–19, 2020.

Nevertheless, the high technical level of the online presentations and the question and answer sessions was unprecedented. The editors of this special issue share the opinion of TPC Chuck Kessel on the fundamental role of the TOFE conference in the agenda of presenting new frontiers and challenges of fusion technology development. With TOFE 2020, we have witnessed a strong interest in fusion problematics from a young generation of researchers and scientists. To encourage submissions to *FS&T* from the young, talented researchers, we have established a section of student competition papers for this special issue. In our future *FS&T* issues, we are continuing to pursue this aim of boosting the scientific careers of young researchers by providing them recognition in the fusion community through publication in the journal. By this strategy, we hope to arouse interest in the young generation and motivate them to participate in the exciting subject of fusion science and technology.

Fusion technology now sees new facilities and growing research activities every year. This year's TOFE technical program demonstrates the growth of our field of study. It was filled with a range of presentations, from neutronics analysis to the tritium fuel cycle, enabling technologies, plasma-facing components, liquid metals, fusion materials, safety systems, blanket systems, and private enterprise. It was a great pleasure to read this work, and we anticipate learning about progress and new discoveries again at the next TOFE meeting.

On a practical note, this special issue of *FS&T* is arranged by category to make finding related papers simpler, as noted in the table of contents. In order, the sections are system-level design and safety; large component design, manufacturing, and analysis; magnet design and analysis; divertor heat management; disruption mitigation via pellet injection; liquid metal analysis; fusion neutronics; tritium systems; and the aforementioned student paper competition selections.

The contents of this special issue reflect the actual state of fusion energy development. This issue encompasses many subjects, overviewed in the foreword from TPC Chuck Kessel. Meanwhile, I (Serikov) would like, in a few paragraphs, to convey some thoughts on my particular area of research interest: neutronics—specifically, recent problems and their solutions, achievements, challenges, and open issues.

Presently, we witness the development of integrated modeling methodology, bridging interdisciplinary areas such as plasma physics, neutronics, materials science and technology, thermodynamics, mechanics, and so on. Coupling of the neutronics and multiphysics codes allows for solving the engineering problems of designing systems and components under high radiation, mechanical, and thermal loads, e.g., for the tasks of plasma–material interactions inside the plasma-facing components of large fusion tokamaks such as JET, DEMO, ITER, and the U.S. Fusion Nuclear Science Facility.

Summarizing the fusion neutronics specifics and challenges of large fusion tokamaks and stellarators, we can highlight the following six points:

1. The three-dimensional geometry of substantially heterogeneous computer-aided design (CAD) models of tokamaks and stellarators is complicated.

2. There is an unprecedentedly large volume of 14-MeV neutron sources in deuterium-tritium (D-T) plasma.

3. The Monte Carlo (MC) method of radiation transport is most suitable for such complex geometries, especially for geometries with channels and gaps, which open radiation-streaming pathways.

4. The use of CAD-to-MC geometry conversion is an inevitable part of the neutronics modeling process.

5. Neutron irradiation causes activation of the structural materials up to the bioshield, with wide distribution of the radioactivity sources, including high activation of cooling water.

6. Decay gamma transport must be taken into account for shutdown dose rate calculations combining calculations of radiation transport and activation.

Neutronics open issues have a more experimental than computational nature. We can distinguish two major issues. The first is related to the absence of the volumetric neutron source from D-T or deuterium-deuterium plasmas. At the present time, we have 14-MeV neutrons produced by the point-sized D-T sources of neutron generators, accelerator-driven systems, the hohlraum capsules of the National Ignition Facility, and so on. In all these devices, the size of the neutron source is very small. Therefore, verification of all our neutronics results obtained with the computational models depends on the successful operation of experimental facilities like ITER. The second open issue is about tritium breeding for D-T fusion facilities beyond ITER, e.g., a DEMO fusion tokamak-type reactor. The requirement of a tritium fueling system for the minimum value of tritium breeding ratio (TBR) is 1.05. As heating and diagnostics port systems in DEMO are not well developed and not installed in ports, the "engineering modeling requirement" for TBR should be higher by 10%—that is, 1.15 in the full breeding blanket, making breeding more intense in order to compensate for neutron absorption and leakage in nonbreeding systems of ion cyclotron heating, electron cyclotron heating, diagnostic systems, and so on.

In conclusion, a few words should be said about to whom this special issue will be interesting. Certainly, it is for the research and development specialists working in the wide area of fusion science and technology. We also believe this issue could be useful in broadening the horizons of plasma, materials, and nuclear scientists and engineers, graduates and postgraduates of suitable specialties, and all educated persons who are interested in recent achievements in this exciting area of knowledge. We wish you happy reading!

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