OECD Nuclear Energy Agency
Nuclear Science Committee

OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD) – Fourth Workshop (C5G7-TD-4)

Oak Ridge, TN, USA
May 16-17, 2019

Hosted by Oak Ridge National Laboratory (ORNL)
USA

PROPOSED PROGRAMME

Sponsorship

The 4th workshop for the OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD) – C5G7-TD-4 will be held on May 16-17, 2019 in Oak Ridge, TN, USA, hosted by the Oak Ridge National Laboratory (ORNL), and is a follow up to the previous three workshops.

Increasing efforts have been made to the development of codes for transient calculations of nuclear reactors in recent years. In order to ensure reliable modelling of neutron physics within a state-of-the-art transient code, the neutron kinetics part of such a code should be based on the full-scale calculation of the space-time neutron kinetics equations without the use of the diffusion approximation and spatial homogenization. Such advanced approaches require the verification of neutron kinetics program modules through the cross-verification of codes, which are used to calculate thoroughly defined test cases, or the so-called benchmarks.

However, existing benchmark problems are not able to satisfy the demand for verifying codes/methods for performing the homogenization-free time-dependent transport calculations. On one hand, some of them are simplified diffusion benchmarks, in which the computational domain is composed of several homogeneous regions. On the other hand, some of them have a broad range of sources of uncertainties involved in the calculation, such as the nuclear data, group cross-section preparation procedure, and potentially other computational simplifications, making it difficult to reveal methodical errors of space-time neutron kinetics codes.

The main objective of this benchmark is to specify a series of space-time neutron kinetics test problems with heterogeneous domain description for solving the time-dependent group neutron transport equation. Physical materials in these benchmarks are described by transport macroscopic cross sections. Such benchmarks would allow carrying out verification of developed time-dependent heterogeneous transport deterministic and stochastic codes, and rigorously revealing methodical errors. Moreover, such benchmarks would allow studying possible inaccuracy of spatial homogenization and diffusion approximation in time-dependent cases.

This benchmark was proposed to the Expert Group on Radiation Transport and Shielding (EGRTS) and has been approved by Nuclear Science Committee (NSC) Working Party on Scientific Issues in Reactor Systems (WPRS) in the meeting in February 2015. The C5G7-TD benchmark is being carried out in 3 phases as follows:

a) Phase I: Kinetics Phase – verification of methods/codes for heterogeneous time-dependent neutron transport calculations without feedback;

b) Phase II: Dynamics Phase – verification of methods/codes for heterogeneous time-dependent neutron transport calculations with feedback;

c) Phase III: High-fidelity Phase – uncertainty propagation in high-fidelity multi-physics calculations.

This workshop (C5G7-TD-4) will be held in conjunction with other meetings/workshops in order to facilitate co-ordination and sharing of work. Seven other meetings are being held in ORNL during the same week in order to combine efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis and to make the participation more efficient. The meetings/workshops concerned are:

- *May 14 – May 15, 2019* – Fifth OECD/NEA Sodium Fast Reactor (SFR) Uncertainty Analysis in Modelling (UAM) benchmark meeting (SFR-UAM-5);

- *May 14 – May 15 (morning), 2019* – Sixth COBRA-TF User's Group Meeting (CTF-6);

- *May 15 (afternoon), 2019* – Second meeting on Blind benchmark on OECD/NEA PHWR Thermal-Hydraulics (PHWR-TH-1);

- May 15 – May 16, 2019 – Thirteen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) benchmark meeting (LWR-UAM-13);

- May 15 - May 16 (morning), 2019 – First benchmark meeting on OECD/NEA Multi-Physics Pellet Clad Mechanical Interaction Validation benchmark (MPCMIV-1);

- May 17, 2019 - Kick-off meeting on OECD/NEA TVA Watts Bar 1 (WB1) Multi-Cycle Multi-Physics benchmark (TVA WB1).

Background and Purpose of the Benchmark Workshop

The objective of the work is to define, conduct, and summarise an OECD/NEA Time-Dependent Neutron Transport Benchmark without Spatial Homogenization benchmark – C5G7-TD. The benchmark model is based on the well-established steady-state C5G7 benchmark problems, which were developed to test the capabilities of radiation transport codes that do not utilize spatial homogenization above the fuel pin level. It is a miniature light water reactor (LWR) with sixteen fuel assemblies (mini-core): eight uranium oxide (UO$_2$) assemblies and eight mixed oxide (MOX) assemblies, surrounded by a water reflector. It features a quarter-core radial symmetry in the 2-dimensional (2-D) configuration.

Specification document entitled "Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD)" for Phase I (now Part A) has been finalized. The detailed perturbation law of each exercise, including two additional exercises focusing on the control rod ejection type of transient scenario added in 2018, is described in the specification. There are two sets of kinetics exercises considered in Part A, Phase I of the benchmark: one focusing on the 2-D and the other focusing on the 3-D core configuration.

During the 3rd workshop, two proposals for extending the scope of work of Phase I exercises have been submitted, discussed and approved by the benchmark team and participants. The first one, now known as Part B of Phase I, was to introduce neutron noise (stationary perturbation) to the C5G7 static configuration. The second one, now known as Part C of Phase I, is focused on the transient analysis of miniature reactor in the hexagonal geometry, based on the SFR or VVER designs.

Draft specifications for Phase II have been updated also for discussion and feedback at the C5G7-TD-3 workshop. The motivation of Phase II is that with the completion of the proposed kinetics exercises, the benchmark to be extended to more realistic dynamics exercises, which will take into account the thermal-hydraulic feedback mechanisms. The cross-section libraries for the prompt (Doppler) feedback exercises have been prepared and distributed to the participants.

Scope and Technical Content of the Benchmark Workshop

The technical topics to be addressed at the workshop include:

a)   Discussion on the benchmark specifications for Part B of Phase I;

b)   Discussion of final templates for submission of participants' results for Part B of Phase I;

c)   Discussion of deterministic and Monte Carlo kinetics modelling for Part B of Phase I cases;

d)   Comparative analysis of submitted results for Part A of Phase I;

e)   Discussion of summary report of Part A of Phase I;

f)   Presentations on participants' experience and expertise in time-dependent neutron transport calculations;

g)   Discussion of draft specifications for Phase II - extension of kinetics benchmark cases to dynamics benchmark cases;

h)   Discussion of deterministic and Monte Carlo dynamics modelling for Phase II cases;

i)   Comparative analysis of submitted results for Phase II;

j)   Discussion of reference results for benchmark cases for Phase II;

k)   Presentations on participants' experience and expertise in high-fidelity dynamics calculations;

l)   Defining a work plan and schedule outlining actions to progress on the benchmark activities.

Organization of the Benchmark Workshop

The meeting is organised around the discussion in depth of the benchmark specifications, templates for submission of participants' results, reference solutions, and proposed work plan and time schedule for the OECD/NEA C5G7-TD benchmark activities. The participants are requested to present their modelling and results as well as their experience and expertise in time-dependent neutron transport analysis.

Participation in the Benchmark Workshop

For Benchmark Workshops sponsored by the Nuclear Science Committee (NSC), participation is restricted, for efficiency, to participants in this study and to experts (research laboratories, safety authorities, regulatory agencies, utilities, owners' groups, vendors, etc.) from OECD/NEA member countries nominated by Delegates to the Committee in consultation with official authorities concerned and with the assistance of members of the Nuclear Science Committee.

Organisation and Programme Committee of the Benchmark Workshop

An Organisation and Programme Committee has been nominated to make necessary arrangements for the 3rd Benchmark Workshop and to organize the Sessions, draw up the final programme, appoint Session Chairmen, etc. The members of the Programme Committee are:

Jason Hou – Co-Chair and Co-ordinator

North Carolina State University, USA

Kevin Clarno – Local Host and Co-Chair
Oak Ridge National Laboratory, USA

Victor F. Boyarinov - Co-ordinator
National Research Centre "Kurchatov Institute", Russian Federation

Kostadin N. Ivanov - Co-ordinator
North Carolina State University, USA

Kiril Velkov
Gesellschaft fuer Anlagen und Reactorsicherheit mbH, Germany

Tom Downar
University of Michigan, USA

Andreas Pautz
Paul Scherrer Institut, Switzerland

Maria Avramova
North Carolina State University, USA

Secretariat: **Tatiana Ivanova**
                 Shuichi Tsuda
                 OECD/Nuclear Energy Agency, France

Proposed Programme of the Benchmark Workshop

The proposed programme for the 4th OECD/NEA C5G7-TD Benchmark Workshop (C5G7-TD-4) was drawn-up by the Programme Committee and is enclosed as *Appendix 1*.

Language of the Benchmark Workshop

The official language of the C5G7-TD-4 Benchmark workshop is English.

Proceedings of the Workshop

A summary of the workshop will be published by the OECD/NEA after the meeting. The summary will be distributed free of charge to the participants in the Workshop and to Delegates of the NSC. The programme committee and the session Chairmen will prepare a summary report on the main results of the meeting for presentation to the NSC. Presentations will be available free of charge to the participants to download from participants' restricted area after the workshop.

Contacts and Registrations

A common registrations webpage is made available for the participants of the SFR-UAM-5, CTF-6, PHWR-TH-1, LWR-UAM-13, MPCMIV-1, C5G7-TD-4, and TVA WB1 workshops:

https://onrampmeetings.ornl.gov

Inquiries about registrations can be directed to:

Brad Rearden	**Shuichi Tsuda**
ORNL	OECD/NEA
reardenb@ornl.gov	Shuichi.TSUDA@oecd-nea.org

Please send titles and authors of your presentations for C5G7-TD-3 to Jason Hou (jason.hou@ncsu.edu).

Workshops' Location

The meeting place for the seven workshops during the week of May 13-17, 2019 is the ORNL Conference Canter at ORNL.

The information for transportation and hotels is provided at the links below:

https://onrampmeetings.ornl.gov/lodging/

The programme and schedule of the meetings is shown below:

Location/Time	Monday May 13			Tuesday May 14			Wednesday May 15			Thursday May 16			Friday May 17	
	TN A	TN B	Tours	TN A	TN B	Tours	TN A	TN B	Tours	TN A	TN B	Tours	TN A	TN B
8:30 AM	Opening Plenary						LWR-UAM-13	MPCMIV-1		LWR-UAM-13	MPCMIV-1		TVA WB1	C5G7-TD-4
9:00 AM	SFR-UAM-5	CTF-6		SFR-UAM-5	CTF-6									
10:30 AM	Coffee Break													
10:45 AM	SFR-UAM-5	CTF-6	IFEL	SFR-UAM-5	CTF-6	IFEL	LWR-UAM-13	MPCMIV-1	IFEL	LWR-UAM-13	MPCMIV-1	IFEL	TVA WB1	C5G7-TD-4
12:00 PM – 1:00 PM	Lunch													
1:00 PM	SFR-UAM-5	CTF-6	Reactors	SFR-UAM-5	PHWR-TH-1	OLCF	LWR-UAM-13	MPCMIV-1	Reactors	LWR-UAM-13	C5G7-TD-4	OLCF	TVA WB1	C5G7-TD-4
2:30 PM	Coffee Break													
2:45 PM	SFR-UAM-5	CTF-6	Reactors	SFR-UAM-5	PHWR-TH-1		LWR-UAM-13	MPCMIV-1	Reactors	LWR-UAM-13	C5G7-TD-4		TVA WB1	C5G7-TD-4
6:00 PM - 9:00 PM	Welcome Reception													

IFEL: ORNL Irradiation Fuels Examination Laboratory

OLCF: ORNL Leadership Computing Facility

Reactors: Historic Graphite Reactor and High Flux Isotope Reactor

Appendix 1

OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD) – Fourth Workshop (C5G7-TD-4)

Host Organization
Oak Ridge National Laboratory

Location
Oak Ridge, TN, USA

May 16-17, 2019

PROPOSED PROGRAMME

C1-17 : Session code

C1. Introduction and opening remarks

C2. Overview of benchmark activities

C3. Presentations on related activities

C4. Discussion of the draft Specifications for Part B of Phase I

C5. Discussion of the requested output and template for the results submission for Part B of Phase I

C6. Comparative analysis of submitted participants' results for Part A of Phase I

C7. Participants' presentations on their modelling and results for time-dependent neutron transport calculations

C8. Participants' presentations on their modelling and results for neutron noise calculations

C9. Discussion of cross-section sets, and libraries prepared with SCALE-6.2 for Phases I and II

C10. Discussion of draft summary report of Part A of Phase I

C11. Discussion of the draft Specifications for Phase II

C12. Discussion of the selected dynamics test problems and requested output for Phase II

C13. Discussion of reference solutions for Phases II

C14. Comparative analysis of submitted participants' results for Phase II

C15. Participants' presentations on their expertise and experience in high-fidelity dynamics modelling and results

C16. Action items and schedule of benchmark activities - next workshop (C5G7-TD-5) and plans

C17. Conclusions and closing remarks