PHYSOR 2014

INTERNATIONAL CONFERENCE

"The Role of Reactor Physics toward a Sustainable Future"

28th Sep. - 3rd Oct., 2014
The Westin Miyako, Kyoto, Japan

Technical Summary of PHYSOR2014

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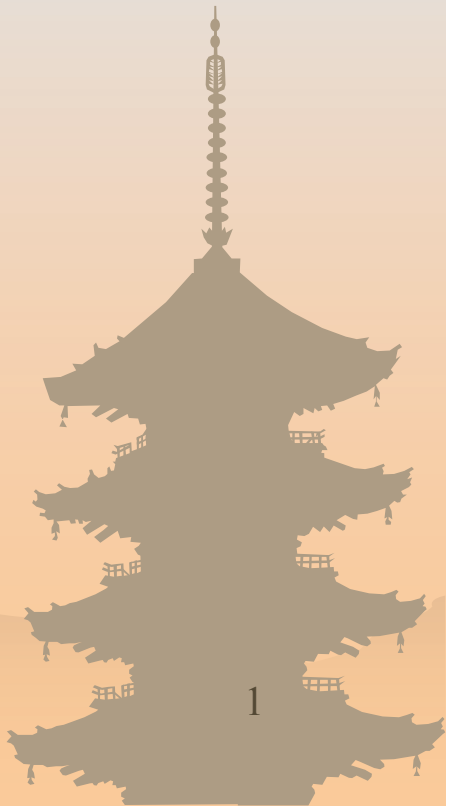


We still have many open problems in reactor physics

- Many excellent advances in the reactor physics field have been presented in PHYSOR2014.
- Also, many unresolved issues are recognized throughout the conference.
- These "issues to be addressed by the reactor physics community" are summarized.

Reactor Analysis Methods

- Good reference solutions particularly for coupled physics problems.
- Good, plant-level, non-proprietary measured data for validation.
- Efficiency of full-core pin-by-pin methods for broader use of this type of method.
- Accurate prediction of pin powers for challenging situations (e.g. MOX/UO2 core) with industry level production codes

Reactor Analysis Methods

- Homogenization method in various types of reactors – non LWR reactors, especially for HTGR.
- Efficient treatment method for geometrical deformation or distortion of core/fuel
- Application of the reduced order modelling to more practical problems, e.g., issues related to commercial reactors.
- Cross section uncertainties of iron for pressure vessel fluence calculations

Reactor Analysis Methods

- Efficient computing methods for the current and next generation computers considering architecture of CPU, e.g., memory bandwidth, cache structure
- Generation of optimized energy structure for practical core analysis codes
- Fidelity of discontinuity factor in highly heterogeneous cores and its correction/adjustment methods

Deterministic Transport Theory

- Direct 3D MOC calculation is still impractical for commercial reactor analysis
- Treatment of axial angular flux distribution in 1D/2D or 2D/3D coupling transport methods
- Higher parallel efficiency with CMFD acceleration
- Unified interpretation/discussion of advantages/disadvantages of CMFD based acceleration methods for various applications.

Monte Carlo Methods

- Convergence and the correlation of local tally
- Efficient (high efficiency, reduced memory) sensitivity/uncertainty evaluation methods based on continuous energy MC
- Treatment of random distribution of particles with various shapes/sizes
- Instability of MC based multi-physics calculations due to statistical deviation
- Multi-group cross sections generation and impact of their uncertainties on core characteristics

Verification, Validation and Uncertainty Analysis

- Full 3-D high fidelity deterministic simulations of "unconventional" systems (research reactors, prototypes, etc.) considering strong axial heterogeneities
- Development of sensitivity analysis tools for various types of core as practical design tools.
- Inconsistency of predicted and measured uncertainties of pin-power distribution in critical experiments.

Verification, Validation and Uncertainty Analysis

- UQ not only for XSs, but also for other parameters – geometry, FP yields, TH conditions in actual reactors
- Fidelity of UQ results obtained by the random sampling method
- Quantification of uncertainties in calculation modeling, adequacy of XS adjustment including modeling errors.

Verification, Validation and Uncertainty Analysis

- Reduction of Pu238 cross section uncertainty for ADS analysis – some experiments would be necessary.
- New data covariance for branching ratio of Am241 and Pu238(n,fission)
- Uncertainties on individual fission yield and cumulative fission yield need to be improved and expanded to include more isotopes
- Covariance data for many reactions need to be available on a more "refined" energy mesh

Nuclear Criticality Safety

- Reasonable criticality calculation model of fuel debris (in Fukushima Daiichi damaged core)
- Full core Monte Carlo calculation with pin/pellet-level burnup
- Uncertainty Quantification due to input parameters and analytical modeling to enhance the reliability for spent fuel criticality accident analysis
- V&V for gamma transport calculations during criticality accident

Reactor Physics Experiments

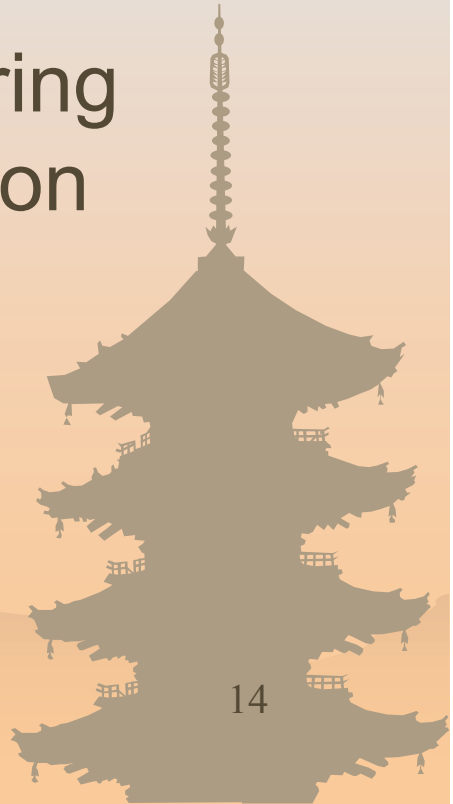
- Large discrepancy between the measured and predicted isotopic inventories in PIE analysis
- Critical experiments for accident tolerant fuel, such as U3Si2 with new cladding
- Incorporation of resonance scattering model for ultra-fine group calculation methods
- Further compilation of experimental data for intermediate spectrum systems
- Measurement of sub-criticality is still a challenging and rich topic of ongoing.

Reactor Concepts and Designs

- Accurate modeling of systems
- Benefits of flexible design (in terms of breeding ratio or other characteristics), achieving long life core
- Overarching approach to guarantee safe behavior through appropriate feedback design and other approaches.

Reactor Operation, Transient and Safety Analysis

- Actual plant measurement data for the verification of transient calculations
- Uncertainty estimation considering material properties and thermal-hydraulics
- Extensive validation framework considering multi-physics effect, numerical comparison among various codes



Nuclear Data

- Adequacy of delayed neutron fraction and S(α,β) data
- Wider communications and feedbacks between reactor physics and nuclear data
- Significant difference still exists among major nuclear data files, JENDL, JEFF, ENDF/B

Research Reactors and Spallation Sources

- Accurate estimation of kinetic parameters with fixed source of ADS.
- Deeper analysis/understanding for spatial dependence of detector position on the measurement of subcritical kinetic parameters (e.g. neutron generation time, sub-criticality level, delayed neutron fraction)

Fuel Cycle and Actinide Management

- Mechanistic multi-physics modeling of fuel performance (including reactor physics) for novel fuels include Th oxide fuel
- Discussion on the potential role (burner or breeder) of ADS depending on the objectives of the fuel cycle strategy
- Integral experimental validation for cross sections of Th-232, U-233, Pa.

Radiation Applications and Nuclear Safeguards

- Use of exotic particle (e.g., anti-neutrino) detection for non-proliferation purpose
- Efficient simulation of cross correlation measurements using Monte-Carlo method

Education in Reactor Physics

- Gap between up-to-date industrial methods and reactor physics theory learned during university lectures
- Modular, web-based, up-to-date educational materials
- Incorporation of real radiation measuring techniques and nuclear reactor experiments

Research related to Fukushima Accident

- Criticality calculation for damaged fuel assembly due to accident – geometrical deformation, treatment volatile fission products, etc.
- Criticality calculations under extremely low moderation condition in fuel racks
- Measurement of actual fuel debris composition for intermediate fuel storage – use gamma spectroscopy.

Molten Salt Reactors

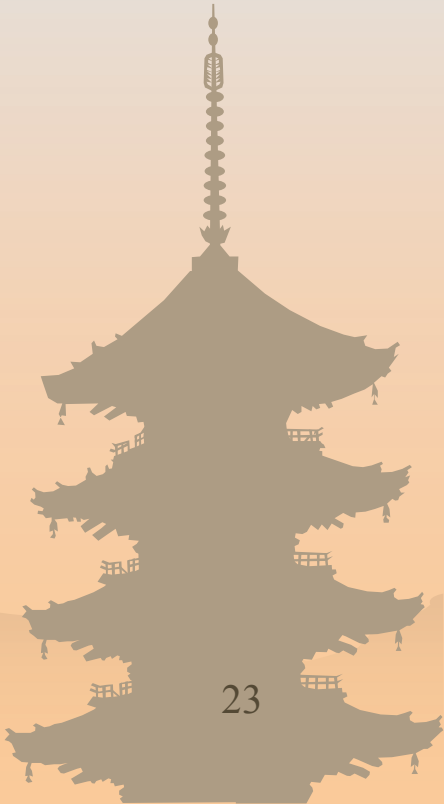
- Deeper understanding of why the traditional derivation of reactor kinetic approximations, notable that of the point kinetic approximations, does not work in MSR.
- A benchmark for MSR including depletion.
- Flux monitoring and establishing of safety criteria should be provided

Reactor Physics and Criticality Safety Activities in OECD/NEA Working Party

- The uncertainty due to nuclear data is significantly larger than the measurement uncertainty.
- Some noticeable discrepancies between the k-effective were observed in sodium cooled fast reactor neutronic benchmark

Hybrid Particle Transport Methods for Solving Complex Problems in Real-time

- A new benchmark suite for 3D, heterogeneous whole reactor core of various types



Advanced Geometry Processing in Deterministic and Monte Carlo Methods

- Efficient determination of regions during transport calculation on a neutron path line, especially in large and complicated geometry
- Efficient access to cross section data for numerous number of flat flux/material regions
- Default standard geometry processing system

Multiscale, Multiphysics Approaches in Nuclear Science and Engineering Applications

- “True” multi-physics calculation with tight and nonlinear coupling of difference physics calculations is still on-going
- UQ method for multi-physics calculation

Reactor Physics of Non-Traditional LWR Fuel Design

- Attract young students through experience of advanced fuel design, which significantly increases tolerance for severe accident
- Significant uncertainty related to novel fuel performance under irradiation, incomplete knowledge of all relevant properties.
- Economics of novel fuels
- The licensing process and path to deployment of novel fuel forms

Technical summary

- Many problems still need to be addressed…
- Progresses will be presented in the next PHYSOR2016 meeting!