2008 INTERNATIONAL SCHOOL IN NUCLEAR ENGINEERING

SACLAY, France

9 Doctoral-level Courses in Advanced Nuclear Science
From September 1st to October 30, 2008

Please visit our website: http://www-instn.cea.fr
The National Institute for Nuclear Science and Technology (INSTN) and the Nuclear Energy Division (DEN) of CEA are continuing their international school in Nuclear Engineering, aiming at promoting knowledge in the field of reactor physics and engineering at a high education level.

This second session will offer 9 advanced courses in nuclear engineering (one module per week) to be held in Saclay, France, in September and October 2008.

These doctoral-level courses address both PhD students and post-docs in nuclear research. 3 ECTS will be awarded for each successfully completed course. These courses are also well suited for established engineers wishing to further their knowledge or diversify their skills.

The lecturers are internationally known experts from leading universities and research institutes in the nuclear field.

### OUTLINE PROGRAM of COURSES

#### 1. Reactor Core Physics: Deterministic and Monte Carlo Methods

*Profs. R. Sanchez and C. Diop*

- **I** • The Neutron Transport Equation
- **II** • Methods for Solving Functional Equations
- **III** • Scattering Operator and Angular Approximations
- **IV** • Computational Methods for Structured and Unstructured Meshes
- **V** • The APOLLO-2 Spectral Code and Application
- **VI** • The Monte Carlo Method for Solving the Transport Equation
- **VII** • Fixed Source, Criticality, Adjoint, and Perturbation Problems; Variance Reduction Techniques
- **VIII** • Monte Carlo Codes

#### 2. Materials for Reactor Fuels and Structures

*Prof. C. Lemaignan*

- **I** • Irradiation Damage by Neutrons
- **II** • Irradiation Damage by Photons and Electrons
- **III** • Behavior of Ferritic Steels (LWR Pressure Vessel) Under Irradiation
- **IV** • Behavior of Austenitic Stainless Steels (LWR Internals and Cladding in FR) Under Irradiation
- **V** • Behavior of Zirconium alloys (Fuel Cladding and LWR Assemblies) Under Irradiation
- **VI** • Fuel Materials
- **VII** • Specific Materials and/or Conditions
LWR and FR Thermal-Hydraulics, Fuel Design, Safety and Risk Assessment
(Profs. M. Corradini and J. Blanchard)

I • Description of Fast Reactors from a Safety Point of View
II • Safety Philosophy for Liquid Metal Cooled Fast Reactors
III • Liquid Metal Cooled Fast Reactor Reactivity Coefficients
IV • Stability Considerations and Safety
V • Fuel Element Behavior, Types of Accidents and Range of Consequences
VI • Mathematical Models of Fast Transients
VII • Bethe-Tait Analysis and its Implications for Licensing
VIII • Plutonium Hazards
IX • Gas Cooled Fast Reactor Safety
X • Potential for Disassembly Accidents
XI • Transition Phase, Fuel Coolant Interactions and Work/Energy Considerations
XII • Loss of Flow, Transient Overpower, and Loss of Heat Sink Accidents
XIII • Post Accident Heat Removal
XIV • Risk Assessment Considerations for Fast Reactors
XV • Licensing and Regulatory Issues for Fast Reactors

LWR Core Physics and Fuel Management
(Prof. P. J. Turinsky)

I • Nuclear Fuel Cycle
II • Core Design
III • Nuclear Fuel Management
IV • Core Characteristics
V • Overview of Computational Methods

Experimental Validation and Calibration of Numerical Simulation Models
(Prof. D. G. Cacuci)

I • Measurements Errors and Uncertainties: Basic Concepts
II • Local Sensitivity and Uncertainty Analysis of Linear and Nonlinear Systems
III • Global Optimization and Sensitivity Analysis
IV • Statistical Methods for Uncertainty Analysis
V • Applications of the Adjoint Sensitivity Analysis Procedure (ASAP) to Two-Phase Flow Systems
VI • Data Evaluation and Models of Error Covariances
VII • Data Adjustment and Assimilation
6 Reactor Kinetics and Dynamics  
(Prof. J. Domling)

I  •  Point Reactor Kinetics Equations  
II  •  Kinetics of Pulses of Neutrons in Non-Multiplying and Subcritical Multiplying Systems  
III  •  Space-Time Reactor Kinetics  
IV  •  Reactor Dynamics: Thermal and Thermo-Hydraulic Feedback  
V  •  Early Nonlinear Analyses of Nuclear Reactor Dynamics  
VI  •  Nonlinear Dynamical Systems Analysis of Boiling Water Reactors  
VII  •  Nonlinear Dynamics and Stability of Future Reactor Systems

7 Neutronics Experiments and Simulations  
(Profs. A. Santamarina and F. Foulon)

I  •  The Verification & Validation & Qualification Method  
II  •  Experimental Facilities and Measurement Techniques  
III  •  Qualification of Neutronics Code Packages - Feedback on Nuclear Data  
IV  •  Typical Neutronics Experiments in the MASURCA and OSIRIS Reactors  
V  •  Approach to Criticality, Reactor Start-up and Reactivity Control (practical work on the ISIS Reactor)  
VI  •  Control Rod Calibration and Global Worth, Temperature Effects (practical work on the ISIS Reactor)

8 Reactor Dismantling and Waste Management  
(Profs. B. Bonin and M. Cumo)

I  •  Overview of Nuclear Decommissioning  
II  •  Decontamination Techniques  
III  •  Safety and Environmental Protection Issues  
IV  •  Decommissioning Costs Evaluation, Standards and Regulations  
V  •  Waste Management Options  
VI  •  Waste conditioning: Glass and Concrete  
VII  •  Spent Fuel as a Confinement Matrix  
VIII  •  Waste disposal: Interim Storage and Geological Disposal  
IX  •  Safety of Storage and Disposal Facilities

9 Fuel Cycle Back-End and Reprocessing  
(Prof. B. Boullis)

I  •  The Front-end Cycle  
II  •  The Spent Nuclear Fuel  
III  •  Uranium and Plutonium Reprocessing: the PUREX Process  
IV  •  Reprocessing of Minor Actinides  
V  •  Advanced Fuel Cycles for Sustainable Nuclear Systems
VENUE: The courses will be held at the INSTM located in the CEA Saclay Center (20 km southwest of Paris).

REGISTRATION DEADLINE: June 27, 2008

REGISTRATION FEE: 2 000 € for the first course + 500 € per additional course. Fee covers lectures, documentation, lunches and buses. Grants are available for students (500 € per course).

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INFORMATION

- **Course 1** Reactor Core Physics: Deterministic and Monte Carlo Methods
  *from September 1st to September 5*

- **Course 2** Materials for Reactor Fuels and Structures
  *from September 8 to September 12*

- **Course 3** LWR and FR Thermal-Hydraulics, Fuel Design, Safety and Risk Assessment
  *from September 15 to September 19*

- **Course 4** LWR Core Physics and Fuel Management
  *from September 22 to September 26*

- **Course 5** Experimental Validation and Calibration of Numerical Simulation Models
  *from September 29 to October 3*

- **Course 6** Reactor Kinetics and Dynamics
  *from October 6 to October 10*

- **Course 7** Neutronics Experiments and Simulations
  *from October 13 to October 17*

- **Course 8** Reactor Dismantling and Waste Management
  *from October 20 to October 24*

- **Course 9** Fuel Cycle Back-End and Reprocessing
  *From October 27 to October 30*
James Blanchard is currently a Professor of Nuclear Engineering at the University of Wisconsin-Madison. He has published more than 80 journal articles in a wide-range of research areas, including fission reactor fuel thermomechanics, fusion reactor safety and design, failure of structures in high heat flux environments, and radioisotope power source design and development.

Bernard Bonin has a background in basic research in High Energy Physics and Materials Physics. He headed the Research and Studies on Nuclear Waste Service, steering the scientific basis for nuclear waste management, with special interest in the migration of radioactive contaminants in underground environment. In 2000, he was appointed assistant to the Director of R&D in COGEMA, in charge of the fuel cycle front-end and future nuclear energy systems. He received the AREVA Innovation Award in 2002 for the development of a radon detection system. Since 2003, he is deputy scientific Director in the Nuclear Energy Division of CEA.

Bernard Boulis is Program Director of Fuel Cycle Technologies and Waste Management at CEA. He was formerly head of the Radiochemistry and Processes Department, specializing in the back-end of the fuel cycle: spent fuel reprocessing, long-lived radionuclides, partitioning & transmutation and innovative technologies for future nuclear systems. He is a Professor at INSTN (CEA) and at the Montpellier University.

Dan Gabriel Cacuci is currently in charge of the Scientific Direction of the Nuclear Energy Division of France’s CEA, and is also Chaired Professor and Director of the Institute for Nuclear Technology and Reactor Safety at the University of Karlsruhe, Germany. Since 1984, Prof. Cacuci has been the Editor of “Nuclear Science and Engineering – The Research Journal of the American Nuclear Society”. He is a member of the European Academy of Sciences and Arts, has won numerous international awards, and has authored 3 books and over 160 peer-reviewed articles on topics in nuclear engineering and atmospheric sciences.

Michael Corradini is Chair and Wisconsin Distinguished Professor of Nuclear Engineering at the University of Wisconsin-Madison. He is a member of the US SRC Advisory Committee on Reactor Safeguards, and the DOE Nuclear Energy Research Advisory Committee. He has published in nuclear safety, severe accident phenomena, vapor explosions, jet spray dynamics and transport phenomena in multiphase systems. He is a member of the US National Academy of Engineering. In 2004, he was appointed as a board member of the INPO National Accreditation Board for Nuclear Training and the National Council on Radiation Protection.

Maurizio L. Cuomo is currently Professor of nuclear plants at the University of Rome La Sapienza, where he chairs the courses of Energetics Engineering and the PhD triennial courses in Energetics. He has authored 5 books and many papers on reactor safety, thermal-hydraulics, and nuclear plants decommissioning for LWRs and FBRs. He is a member of the Italian Academy of Sciences (said of the Forty), of the European Academy of Sciences and Arts and chairs the Italian Society for the Advancement of Sciences.

Cheikh M’Backe Diop works at the Service of Reactor Studies and Applied Mathematics (CEA). He was the head of the Laboratory of Shielding Studies and Probability at CEA. He is co-author of a book on Radiation Protection and Nuclear Engineering. He teaches the radiation shielding computational methods and the Monte Carlo method for simulating the particle transport in matter, at INSTN (CEA) and at the Orsay University.

John J. Dorning is the Whitney Stone Professor of Nuclear Science and Engineering, of Applied Mathematics, and Engineering Physics at the University of Virginia. He has done extensive theoretical research on reactor kinetics, reactor dynamics, reactor physics, and neutron transport theory. He also has developed advanced computational methods in all these areas and in fluid flow and heat transfer. He has received numerous honors and awards for his research – including the E.O. Lawrence Award in Nuclear Energy (US DOE) and the ANS A.H. Compton, E.P. Wigner and G.T. Seaborg Awards –, and he is a member of the US National Academy of Engineering.

François Foulon has a background in material physics and nuclear instrumentation. He headed research on nuclear detectors including neutron detectors for reactor operation. He joined the INSTN in 2000, managing the ULYSSE reactor dedicated to training. He gives lectures in nuclear physics, reactor physics and reactor operation. He is in charge of the training courses on reactor operation on the ISIS reactor at CEA Saclay.

Clément Lemaignan is a Research Director at CEA and a Professor at INSTN (CEA) and Grenoble INP, specializing on nuclear metallurgy, physics of fractures and material science. Prof. Lemaignan holds 4 patents, and has authored 3 books, 6 book chapters, and over 70 peer-reviewed articles. He is an Editor for the Journal of Nuclear Materials. For his research and teaching, Prof. Lemaignan has received many distinctions, and is an Officer of the Palmes Académiques.

Richard Sanchez is Research Director at CEA, specialized in transport theory, numerical methods, large-scale computer codes and reactor physics modeling. He is professor at INSTN (CEA) and adjunct professor at Georgia Institute of Technology, Nuclear and Radiological Engineering/Medical Physics.

Alain Santamarina is Research Director at CEA. He is Professor of neutronics at INSTN (CEA), was head of Eole and Minerve teams, and the ITER neutronics/shielding and EFF nuclear data library. Professor Santamarina is an Officer of the Palmes Académiques.

Paul J. Turinsky is Professor of Nuclear Engineering at North Carolina State University, specializing in computational reactor physics, with a focus on nuclear fuel management optimization, space-time kinetics, sensitivity/uncertainty analysis and adaptive core simulation. He has won numerous awards, including the E.O. Lawrence Award in Nuclear Energy (US DOE), E.P. Wigner Reactor Physics Award (ANS) and A.H. Compton Award (ANS).