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K. E. Sale

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CURRENT STATUS OF RADIATION TRANSPORT TOOLS FOR PROLIFERATION AND TERRORISM PREVENTION

Kenneth E. Sale
Lawrence Livermore National Laboratory
Livermore, California, USA

Abstract

We present the current status and future plans for the set of calculational tools and data bases developed and maintained at LLNL. The calculational tools include the Monte Carlo codes TART[1)] and COG[2)] as well as the deterministic code ARDRA[3)]. In addition to these codes presently in use there is a major development effort for a new massively parallel transport code.

An important part of the capability we're developing is a sophisticated user interface, based on a commercial 3-D modeling product, to improve the model development process. A major part of this user interface tool is being developed by Strela[4)] under the Nuclear Cities Initiative. Strela has developed a hub-and-spoke technology for code input interconversions (between COG, TART and MCNP) and will produce the plug-ins that extend the capabilities of the 3-D modeler for use as a radiation transport input generator. The major advantages of this approach are the built-in user interface for 3-D modeling and the ability to read a large variety of CAD-file formats.

In addition to supporting our current radiation transport codes and developing new capabilities we are working on some nuclear data needs for homeland security. These projects are carried out and the Lawrence Berkeley National Laboratory 88" cyclotron and at the Institute for Nuclear Research of the National Academy of Science of Ukraine under an STCU contract.

The Proliferation and Terrorism Prevention (PTP) Program at LLNL

The Proliferation and Terrorism Prevention (PTP) Program at LLNL is part of the Nonproliferation, Arms Control and International Security Directorate (NAI). The work in PTP is funded by several sponsors. The main program sponsors are the US Departments of Homeland Security (DHS) and of Energy (DOE). Nuclear nonproliferation programs have been part of DOE's mission since it was created, the core mission of DHS is counter terrorism. Within PTP the Radiation Technology Group works in areas relevant to both of these missions. Professor Prussin will discuss a specific DHS project being conducted by PTP.

Radiation Transport Modeling for PTP

Computational modeling is a crucial tool for many of the nuclear nonproliferation and radiological/nuclear counter terrorism programs in that trusted computational tools, properly used can save a treat deal of time, effort and costs. As an example, it would be prohibitively expensive and time consuming to test a radiation portal monitor with respect to even a small fraction of the innocent materials that cause nuisance alarms or threat items. It is feasible to create models of items, predict detector signals and subject the predicted signals to the analysis algorithm used in the instrument. Well planned testing with real materials along with careful and much more exhaustive testing with calculated signals can provide reliable assessments of the performance of radiation detection systems.

At LLNL we apply a large set of radiation transport tools to our problems. Some of these tools have been developed at LLNL, some at other places. In this paper the LLNL-developed tools will be discussed along with the future directions or our tools development plans.

The two time-tested, workhorse tools for radiation transport at LLNL are the codes TART[1)] and COG[2)]. COG is our "full physics" code; the default is that COG uses all the physics information available in the databases. This means that the cross sections are pointwise defined and continuous in energy and angle. The geometry description is a sophisticated combinatorial method, fully three dimensional and including capabilities for handling multiple copies of sub-geometries, arbitrary scaling, translation and rotations and a wide array of measurement units. An important capability of COG is the ability to link to user-defined particle source and detector/tally routines at run-time. The second widely used and well tested code maintained at LLNL is TART. This is a very widely used code. The particle energies are continuous with groupwise cross sections (augmented by corrections for neutron transport including a multi-band method to handle resonance self-shielding).

Codes presently under development and beginning to be used are Ardra[3)] and MERCURY, a 3-D deterministic solver and a massively parallel Monte Carlo code respectively.

Example Applications

Each year 48 million cargo containers move among the world's sea ports and only a small fraction are thoroughly inspected. This means that seaports are vulnerable to a terrorist attack. Illicit radioactive or nuclear materials could be hidden and transported easily. At LLNL there is a major effort to develop technology to counter this threat[5)]. The method being developed is the active interrogation of cargo containers with neutrons. A neutron generator floods the container with a burst of neutrons. If the neutrons encounter any fissile material fission will be induced. The telltale neutrons and gamma-rays produced, including beta-delayed emission, will be detected by an array of detectors surrounding the container. Extensive modeling has been done to assess the concept indicating that there is a substantial signal from beta-delayed emission which can be detected. From the models it is clear that the detection will be challenging. Without the modeling tools that have been developed and used it would have been impossible to determine that the approach we feasible without a huge investment of time and resources to build and demonstrate the concept. As the project progresses modeling is used to design and assess the safety of the facility and to expand the range of the assessments far beyond the set of experiments and tests that can be conducted. One of the challenges being faced now is the lack or inadequate quality of nuclear data in the databases the codes use. As the range of problems being addressed grows data that has been unimportant in the past becomes crucial and low-resolution data which was good enough before is no longer satisfactory. The expanded data needs of counter-terrorism work are being addressed in several ways, including cooperation on nuclear data measurements with the Lawrence Berkeley National Laboratory 88" cyclotron facility and the Institute for Nuclear Research of the National Academy of Science of Ukraine under an STCU contract.

New Tools and Future Directions

The development work going on at LLNL include work on Ardra, a fully-3D, time dependent S_n code, and MERCURY, a new massively parallel Monte Carlo code, several helper tools and a major effort with Strela[4)] to develop a next-generation input generation tool.

One of the very exciting developments underway now is the joint project between LLNL and Strela to create a new input generator tool. This project has several goals. The first is to address the tedious and error prone nature of generating input for radiation transport codes. There are two keys to the new tool, a commercial geometry modeler (FormZ) with a very sophisticated user interface and extensive capability to use common CAD file formats and a set of plug-ins to provide the extra capabilities needed for generation of transport code inputs. When this project is complete it will be far easier for a person to generate an accurate and error-free input for the common radiation transport codes. An additional benefit of this approach to input generation is the ability to interconvert among the code input formats that are supported, for example it will be possible to convert input files to and from COG, TART, MCNP and MERCURY formats making code intercomparisons much easier. Also the sophisticated geometry rendering and checking capability of FormZ will be available making geometry debugging far easier and more reliable than at present.

A handful of other small tools have been or are being developed as well. These include a three dimensional geometry renderer based on the VisIt[6)] visualization tool, a source specification tool which generates input for a radioisotope and all daughters at an arbitrary age.

Summary

In support of the Proliferation and Terrorism Prevention Program at LLNL several time-tested radiation transport tools are being maintained, developed and supported. These tools include COG, TART and nuclear data work. In addition we are preparing for the future needs of this and other programs by developing a set of powerful new tools that will make higher fidelity, more complete models and calculations possible at much lower cost in time and effort. The main new tools under active development are MERCURY and a powerful and user-friendly input generator. The continuing growth in parallel computing power together with the new tools being developed will lead to a substantial improvement of the usefulness and usability of radiation transport tools in proliferation and terrorism prevention.

References

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6) http://www.llnl.gov/VisIt/

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