Center for Exascale Radiation Transport

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The Center for Exascale Radiation Transport (CERT) is led by Texas A&M University with the University of Colorado and Simon Fraser University as partners. CERT research includes development of exascale algorithms for thermal radiation propagation in the high energy density physics (HEDP) regime, general purpose exascale computer-science algorithms, numerical methods and subgrid models for radiation propagation, and experiments that test computational predictions and associated uncertainty quantification. The CERT project has been funded since March 2014, but five faculty members on their team have worked on either one or both of the PSAAP projects associated with the PECOS Center at the University of Texas and the CRASH Center at the University of Michigan. Furthermore, seven faculty members on the CERT team have a decades-long history of collaborations with NNSA laboratories. They have collectively sent many graduates to NNSA laboratories as postdoctoral fellows or staff members. Last year, CERT faculty had three PhD graduates hired at NNSA national laboratories as either postdoctoral fellows or staff members.

Professor Jim Morel, Director of CERT and Project Principal Investigator, states, "The SSAP funding for CERT has enabled our faculty and students to engage in an integrated research program with resources sufficient to vastly improve the predictive capability of thermal radiation propagation calculations for NNSA applications, and to broaden our existing collaborations with NNSA laboratory staff."

Currently, exascale computers are being developed to perform 10^{18} (one quintillion) operations per second. These computers have the potential to be nearly 50 times faster than the fastest currently existing computers. However, computing on exascale machines will present new challenges relative to current machines, due to the need to drastically reduce both energy consumption per processor and RAM per processor. Another challenge is that computational errors may routinely occur during calculations with far greater frequency than they currently occur. In addition, the cost of moving data relative to the cost of computing with data will dramatically increase.

Thermal radiation propagation is of primary importance to a variety of NNSA programs including those associated with the National Ignition Facility at Lawrence Livermore National Laboratory, the Z Machine at Sandia National Laboratories, and many aspects of stockpile stewardship. Simulations of HEDP experiments involve many types of physics. Thermal radiation propagation calculations are a primary component of such simulations and generally consume far more computational resources than any other type of physics calculations. Thus, efficient HEDP simulations demand efficient radiation propagation calculations. CERT researchers recently developed a new model of parallel performance for radiation propagation algorithms that is enabling them to pinpoint and eliminate bottlenecks in their algorithms. Radiation propagation calculations using approximately 500,000 processors with a speedup of roughly 300,000 relative to computing on a single processor have been performed recently. A unique aspect of the CERT project is the use of neutron experiments as a surrogate for thermal radiation experiments in the HEDP regime. This approach will enable CERT researchers to experimentally determine both the errors in the numerical simulations of experiments and the sources of those numerical errors via hierarchical Uncertainty Quantification methods. The information obtained from the neutron experiments will be equally relevant to both neutron propagation calculations and thermal radiation propagation calculations. This type of information could not be obtained from radiation experiments in the HEDP regime because many types of physics would be required to model the experiments, but only propagation physics is needed to model the neutron experiments.

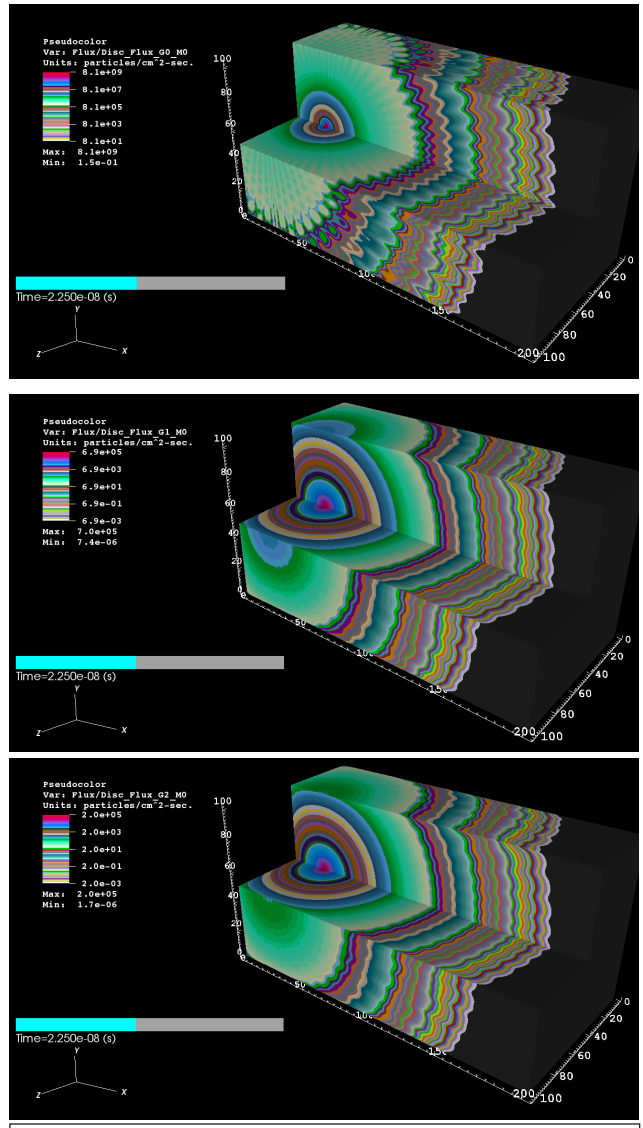

Figure 1. Predicted radiation intensity contours in a typical CERT problem. Top, center, and bottom are high-energy, medium-energy, and low-energy radiation, respectively.

Figure 1 shows predicted solutions for one of the simpler CERT propagation problems.