Gregory Davidson

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Reactor and Nuclear Systems Division

+ CONTACT

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+ RESEARCH INTERESTS

My research interests include deterministic transport algorithms, such as finite element S_N discretizations and time differencing methods, Monte Carlo transport, sensitivity/uncertainty analysis, discrete diffusion Monte Carlo methods, multiphysics methods, transport-depletion coupling methods, hydrodynamics, software engineering, object-oriented programming, programming for massively-parallel systems, especially leadership-class computing, and programming for heterogeneous architectures.

+ RESEARCH EXPERIENCE

My research experience has involved the derivation, analysis, and implementation of deterministic and stochastic numerical radiation transport methods, including:

- Team developer on Exnihilo, a three-dimensional, massively multiparallel radiation transport code designed to scale from laptops to supercomputers, featuring Monte Carlo, S_N, and P_N solvers, hybrid methods, and nuclide depletion. Currently under active development at Oak Ridge National Laboratory.
- Team member in the VERA-RTM group in the Consortium for the Advanced Simulation of Light water reactors (CASL).
- Team member of the MUSE NA-22 project.
- Principle Investigator of the OLCF ALCC Project, "Advanced Simulation of HFIR for LEU Conversion"
- Principle Investigator of Laboratory Directed Research and Development project, "Advanced Modeling and Simulation to Support High-Performance Research Reactor Conversions to Low Enriched Uranium"
- Co-investigator of the ORNL Seed project "Development and Investigation of Advanced Monte Carlo Fission Source Convergence Acceleration Methodologies"
- Sensitivity analysis of radiation flux for nuclear events in urban environments
- Researched the Staggered-Block Jacobi space-time discretization as a student member of the Center for Radiation Shock Hydrodynamics (CRASH) program, and as a Graduate Student Research Assistant and Department of Energy Computational Science Graduate Fellow
- Researched a finite-element transport discretization using Wachspress basis functions as a Department of Energy Computational Science Graduate Fellow
- Various transport research at internships and practicums

+ EDUCATION

December 2009
University of Michigan
Ann Arbor, MI

Ph.D. in Nuclear Engineering and Radiological Sciences and Scientific Computing

Advisor: Edward W. Larsen

Thesis Title: Time-Dependent Radiation Transport using the Staggered-Block Jacobi Method

GPA: 8.15/9.00

July 2004 — M.S. in Nuclear Engineering

Oregon State University
Corvallis, OR

Advisor: Todd S. Palmer

Thesis Title: Finite Element Transport using Wachspress Rational Basis Functions on Quadrilaterals in Diffusive Regions

GPA: 3.93/4.00

July 2002 — Honor's Bachelor's in Nuclear Engineering

Oregon State University
Corvallis, OR

Thesis Title: Finite Element Diffusion Solutions on Arbitrary Quadrilaterals using Wachspress Rational Functions

GPA: 3.94/4.00

+ WORK EXPERIENCE

Dec. 2009 – Present **Oak Ridge National Laboratory (Radiation Transport, RNSD)**

Research and development associate as part of the Shift/Denovo team, investigating advanced, massively parallel radiation transport solutions, including both fixed-source and k-eigenvalue problems, as well as transport-depletion coupling schemes. Also part of the development team of CASL as a member of the VERA-RTM area. Have worked extensively in multicode coupling, including coupling to the XSProc package in Scale for automated cross-section generation, coupling to ORIGEN for depletion calculations, and to the AMP (Advanced MultiPhysics) fuel performance code.

Jun. 2005 – Aug. 2005 **Los Alamos National Laboratory (CCS-4)**

Implemented an emissivity-preserving discrete diffusion Monte Carlo (DDMC) transport scheme in C++. Wrote and tested the asymptotically-correct angular distribution functionality for transport-diffusion interfaces in DDMC methods.

Jun. 2003 – Sep. 2003 **Bettis Atomic Power Laboratory (Reactor Physics)**

Derived the equations for the constant-constant, constant-linear, and linear-linear short characteristics methods on rectangular zones. Wrote the constant-linear characteristics method into an existing S_N code in Fortran 90.

Jun. 2002 – Sep. 2002 **Lawrence Livermore National Laboratory (A Division)**

Researched a finite-element transport method using Wachspress rational basis functions for solving the discrete-ordinates neutron transport equation

Jun. 2001 – Sep. 2001 **Lawrence Livermore National Laboratory (A Division)**

Investigated a one-dimensional computational hydrodynamics scheme based on rational basis functions.

Jun. 2000 – Sep. 2000 **Lawrence Livermore National Laboratory (A Division)**

Implemented relativistic fluid motion corrections and momentum deposition into the particle Monte Carlo package of Kull, a three-dimensional multiphysics code, in C++ and Python.

+ PUBLICATIONS

Journal Publications

A.E. Isotalo, **G.G. Davidson**, T.M. Pandya, W.A. Wieselquist, and S.R. Johnson, "Flux Renormalization in Constant Power Burnup Calculations," Ann. Nucl. Energy **96**, 148-157 (2016).

S.P. Hamilton, T.M. Evans, **G.G. Davidson**, S.R. Johnson, T.M. Pandya, and A.T. Godfrey, "Hot Zero Power Reactor Calculations Using the Insilico Code," J. Comp. Phys **314**, 700-711 (2016).

T.M. Pandya, S.R. Johnson, T.M. Evans, **G.G. Davidson**, S.P. Hamilton, and A.T. Godfrey, "Capabilities, Implementation, and Benchmarking of Shift, a Massively Parallel Monte Carlo Radiation Transport Code," J. Comp. Phys. **308**, 239-272 (2016).

R.N. Slaybaugh, T.M. Evans, **G.G. Davidson**, and P.P.H. Wilson, "Multigrid in

Energy Preconditioner for Krylov Solvers," J. Comp. Phys., **272,** 405-419 (2013).

G.G. Davidson, T.M. Evans, J.J. Jarrell, S.P. Hamilton, T.M. Pandya, and R.N. Slaybaugh, "Massively Parallel, Three-Dimensional Transport Solutions for the *k*-Eigenvalue Problem," Nucl. Sci. Eng. **177,** 111-125 (2014).

J.J. Jarrell, A.T. Godfrey, T.M. Evans, and **G.G. Davidson**, "Full Core Reactor Analysis: Running Denovo on Jaguar," Nucl. Sci. Eng., **175,** 283-291 (2013).

G. Yesilyurt, K.T. Clarno, T.M. Evans, **G.G. Davidson**, and P.B. Fox, "C5 Benchmark Problem with Discrete Ordinate Radiation Transport Code Denovo," Nucl. Tech. **176**(2), 274-283 (2011).

G. Davidson and T.S. Palmer, "Finite Element Transport Using Wachspress Rational Functions on Quadrilaterals in Thick Diffusive Regions," Nucl. Sci. Eng., **159**, 242 (2008).

J.D. Densmore, **G. Davidson**, and D.B. Carrington, "Emmissivity of Discretized Diffusion Problems," Ann. Nucl. Energy, **33**, (2006).

Conference Proceedings

G.G. Davidson, T.M. Pandya, A.E. Isotalo, S.R. Johnson, T.M. Evans, and W.A. Wieselquist, "Nuclide Depletion Capabilities in the Shift Monte Carlo Code," PHYSOR 2016, May 1-5, Sun Valley, ID.

T.M. Pandya, S.R. Johnson, **G.G. Davidson**, T.M. Evans, and S.P. Hamilton, "Shift: A Massively Parallel Monte Carlo Radiation Transport Package," M&C 2015, April 19-23, Nashville, TN.

T.M. Evans, W. Joubert, S.P. Hamilton, S.R. Johnson, J.A. Turner, **G.G. Davidson**, and T.M. Pandya, "Three-Dimensional Discrete Ordinates Reactor Assembly Calculations on GPUs," M&C 2015, April 19-23, Nashville, TN.

R.N. Slaybaugh, T.M. Evans, **G.G. Davidson**, and P.P.H. Wilson, "Rayleigh Quotient Iteration with a Multigrid in Energy Preconditioner for Massively Parallel Neutron Transport," M&C 2015, April 19-23, Nashville, TN.

S. Palmtag, K. Clarno, **G. Davidson**, et. al., "Coupled Neutronics and Thermal-Hydraulic Solution of a Full-Core PWR Using VERA-CS," PHYSOR 2014, Kyoto, Japan.

J.J. Jarrell, T.M. Evans, and **G.G. Davidson**, "Discrete Ordinate Quadrature Selection for Reactor-based Eigenvalue Problems," M&C 2013, Sun Valley, ID May 5-9, 2013.

S. Hamilton, K. Clarno, M. Berrill, T. Evans, **G. Davidson**, R. Lefebvre, and R. Sampath, "Multiphysics Simulations for LWR Analysis," M&C 2013, Sun Valley, ID, May 5-9, 2013.

C.G. Baker, **G.G. Davidson**, T.M. Evans, S.P. Hamilton, J.J. Jarrell, and W. Joubert, "High Performance Radiation Transport Simulations on TITAN," Supercomputing SC12, Salt Lake City, NV, Nov. 12-15, 2012.

J.J. Jarrell, A.T. Godfrey, T.M. Evans, and **G.G. Davidson**, "Full Core Reactor Analysis: Running Denovo on Titan," PHYSOR 2012, Knoxville, TN, April 15-20. On CD-ROM, American Nuclear Society, LaGrange Park, IL, 2012.

R.N. Slaybaugh, T.M. Evans, **G.G. Davidson**, and P.P.H. Wilson, "Rayleigh Quotient Iteration in 3D, Deterministic Neutron Transport," PHYSOR 2012, Knoxville TN, April 15-20. On CD-ROM, American Nuclear Society, LaGrange, Park, IL, 2012.

B. Vacaliuc, D.R. Patlolla, E. D'Avezado, **G.G. Davidson**, et. al., "Python for Development of OpenMP and CUDA Kernals for Multidimensional Data," 2011 Symposium on Application Accelerators in High Performance Computing (SAAHPC'11), Knoxville, TN, July 19-21, 2011.

T.M. Evans, **G.G. Davidson**, and R.N. Slaybaugh, "Three-Dimensional Full Core Power Calculations for Pressurized Water Reactors," Proceedings of the 2010 Scientific Discovery through Advanced Computing (SciDAC) Conference. Chattanooga, Tennessee, July 11-15, 2010. Oak Ridge National Laboratory. http://computing.ornl.gov/workshops/scidac2010/.

G. Davidson and E.W. Larsen, "Sweepless Time-Dependent Transport Calculations using the Staggered Block Jacobi Method," International Conference on Mathematics, Computational Methods, and Reactor Physics (M&C 2009), Saratoga Springs, NY, May 3-7. On CD-ROM, American Nuclear Society,

LaGrange Park, IL, 2009.

G. Davidson and T.S. Palmer, "Finite Element Transport Using Wachspress Rational Basis Functions on Quadrilaterals in Diffusive Regions," Palais des Papes, Avignon, France, September 12-15. On CD-ROM, American Nuclear Society, LaGrange Park, IL, 2005.

Conference Abstracts

S.P. Hamilton, **G.G. Davidson**, T.M. Evans, and K. Banerjee, "Accelerated Monte Carlo Fission Source Convergence with Fission Matrix and Kernel Density Estimators," American Nuclear Society Annual Summer Meeting, June 12-16, New Orleans, LA (2016).

B. Vacaliuc, J.K. Munro, Jr., Z.W. Bell, T.M. Evans, and **G.G. Davidson**, "Accelerated Solution of One-Dimensional Neutron Transport on General Purpose Graphics Processing Unit," International Conference on Preconditioning Techniques for Scientific and Industrial Applications," May 16-18, Bordeaux, France, 2011.

G.G. Davidson, T.M. Evans, R.N. Slaybaugh, and C.G. Baker, "Massively Parallel Solutions to the k-Eigenvalue Problem," Trans. Am. Nucl. Soc., **103** (2010).

G. Davidson and E.W. Larsen, "An Unconditionally-Stable Time-Dependent Transport Method Without Sweeps," Trans. Am. Nucl. Soc., **97** (2007).

G. Davidson, J.D. Densmore, A.K. Prinja, and J.E. Morel, "Asymptotically Correct Angular Distributions for Monte Carlo-Diffusion Interfaces," Trans. Am. Nucl. Soc., **94** (2006).

G.G. Davidson and T.S. Palmer, "Finite Element Diffusion on Arbitrary Quadrilaterals using Rational Basis Functions," Trans. Am. Nucl. Soc., **87** (2002).

Theses

G. Davidson, "Time-Dependent Radiation Transport Using the Staggered-Block Jacobi Method," Doctoral Dissertation, Department of Nuclear Engineering and Radiolocal Sciences, University of Michigan (2010).

G. Davidson, "Finite Element Transport Using Wachspress Rational Basis Functions on Quadrilaterals in Diffusive Regions," Master's Thesis, Department of Nuclear Engineering and Radiation Health Physics, Oregon State University (2004).

G. Davidson, "Finite Element Diffusion Solutions on Arbitrary Quadrilaterals using Rational Basis Functions," Undergraduate Honor's Thesis, Department of Nuclear Engineering and Radiation Health Physics, Oregon State University (2002).

Contributed Presentations

G.G. Davidson, T.M. Evans, R.N. Slaybaugh, and C.G. Baker, "Massively Parallel Solutions to the k-Eigenvalue Problem," American Nuclear Society, Annual Meeting, November 7-11, 2010, Las Vegas, N.V.

G. Davidson and E.W. Larsen, "An Unconditionally-Stable Finite-Element Transport Method Without Sweeps," American Nuclear Society, Annual Meeting, November 11-15, 2007, Washington, D.C.

G. Davidson and T.S. Palmer, "Finite-Element Particle Transport using Wachspress Rational Basis Functions," Computational Science Graduate Fellowship, Annual Conference, June 20-22, 2006, Washington, D.C., available at http://www.cs-pi.org/csgf/conf/2006/presentations/davidson.shtml.

G. Davidson, J.D. Densmore, A.K. Prinja, and J.E. Morel, "Asymptotically Correct Angular Distributions for Monte Carlo-Diffusion Interfaces," American Nuclear Socity, Annual Meeting, June 4-8, 2006, Reno, NV.

G. Davidson and T.S. Palmer, "Finite Element Transport Using Wachspress Rational Basis Functions on Quadrilaterals in Diffusive Regions," Palais des Papes, Avignon, France, September 12-15, 2005.

G.G. Davidson and T.S. Palmer, "Finite Element Diffusion on Arbitrary Quadrilaterals using Rational Basis Functions," American Nuclear Society, Annual Meeting, November 17-21, 2002, Washington, D.C.

+ HONORS AND AWARDS

- R&D100 Award for the Virtual Environment for Reactor Applications (VERA) reactor simulator code.
- 2014 ORNL Engineering Research and Development team award

- Principle Investigator of the ORNL LDRD, "Advanced Modeling & Simulation to Support High Performance Research Reactor Conversions to Low Enriched Uranium"
- Principle Investigator of the ASCR Leadership Computing Challenge, "Advanced Simulation of HFIR for LEU Conversion"
- Awarded the HPC Innovation Excellence Award
- 2012 Oak Ridge National Laboratory Significant Event Award
- 2011 MeV Summer School: Best Technical Paper Award
- American Nuclear Society, Mathematics and Computation Division, Best Paper and Presentation Award, November 2010
- 2010 ORNL Engineering Research and Development team award
- D.O.E. Computational Science Graduate Fellowship Award
- Master's Thesis of the Year, Nuclear Engineering Department, Oregon State University
- Honor's College Member at Oregon State University
- Tau Beta Pi Engineering Honor Society
- Phi Kappa Phi Honor Society
- Alpha Lambda Delta Honorary Fraternity
- National Academy for Nuclear Training Scholarship
- Oregon Space Grant Scholarship
- D.O.E. NEHP Scholarship
- OSU Achievement Scholarship
- Schuette Engineering Scholarship
- Leo Adler Foundation Scholarship
- Sanford Adler Scholarship
- Nadie Strayer Scholarship
- Grant-Baker Federal Credit Union Scholarship
- Elks Scholarship

+ PROFESSIONAL ACTIVITIES

- Member of the American Nuclear Society, 1998-Present
  - Mathematics and Computations Division Executive Committee, 2011-2014
  - Co-chair of the Mathematics and Computations Division Publicity Committee.
  - Vice President of the Student Chapter at Oregon State University, 1999-2000.
- Attended the 2011 MeV Summer School: Reactor Physics, Computations, Validation, and Integration in Multiphysics Codes
- Attended the 2008 Accerators for Science and Engineering Applications: GPUs and Multicores summer school
- Member of the American Nuclear Society, 1998-Present
- Graduate Senator of the Associated Students of Oregon State University, 2004-2006.

+ SKILLS

- Programming Languages: C++, C , Python, Fortran 90
- Code Libraries: C++ Standard Template Libraries, BOOST, Trilinos, Silo, HDF5
- Version Control Software: CVS, Subversion, Git, Mercurial
- Documentation: LaTex, Doxygen, reStructuredText, Wiki markup
- Analysis Software: Mathematica, Matlab, Maple
- Scientific Software: AMP, MCNP, Scale, Attila, VESTA, Serpent
- Office Software: MS Office, OpenOffice