Chonglin Zhang

Mechanical Engineering, University of Michigan
2250 G. G. Brown, 2350 Hayward St.
Ann Arbor, MI 48109
zhangchl@umich.edu
612-206-6153
www-personal.umich.edu/∼zhangchl/

Research Interests

- Direct simulation Monte Carlo (DSMC) stochastic particle method
- Kinetic theory of gases, Rarefied gas dynamics, Transport Phenomena
- Hypersonic thermochemical non-equilibrium flow modeling and simulation
- Fluid mechanics, Micro/nano-scale flow/heat transfer
- Computational Fluid Dynamics (CFD), Scientific Computing

Education

University of Minnesota, Minneapolis, MN

Ph.D. Aerospace Engineering and Mechanics August 2013

- Dissertation: Consistent Modeling of Hypersonic Nonequilibrium Flows using Direct Simulation Monte Carlo
- Advisor: Dr. Thomas E. Schwartzentruber

M.S. Aerospace Engineering and Mechanics May 2010

- Thesis: Adaptive Mesh Refinement and Cut-cell Algorithms for DSMC Simulation of Hypersonic Flows
- Advisor: Dr. Thomas E. Schwartzentruber

Beijing University of Aeronautics and Astronautics, Beijing, China

B.E. Engineering Mechanics School of Aeronautical Science and Engineering July 2007

- Thesis: Numerical Simulation of Fish Locomotion
- Advisor: Dr. Shilong Lan, Dr. Mao Sun

Research Experience

- **Research Fellow**
  Mechanical Engineering, University of Michigan March 2015–

  (1) Developing physical collision/rate models for soot/nano particle formation and growth in combustion.

- **Postdoctoral Research Associate**
  Aerospace Engineering and Mechanics, University of Minnesota September 2013–February 2015

  (1) State-to-state type collision model in the DSMC method based on computational chemistry results, to model hypersonic nonequilibrium phenomena; reduced order thermochemical models informed from state-to-state model, for DSMC and CFD simulation of chemically reacting flows.
  (2) Phenomenological DSMC model to capture the rovibrational coupling effect occuring at high temperature.

- **Graduate Research Assistant**
  Aerospace Engineering and Mechanics, University of Minnesota January 2009–August 2013

  (1) Proposed a new phenomenological nonequilibrium-direction-dependent rotational energy exchange model for rotational nonequilibrium modeling in the DSMC method, based on molecular dynamics simulation results of nitrogen.
  (2) Proposed a new state-to-state collision model framework for the DSMC method, and its consistent implementations; based on the model framework, developed a vibrational state-to-state DSMC collision model using quantum chemistry results.
  (3) Developed an adaptive mesh refinement algorithms and other functions for a Cartesian grid DSMC code (MGDS code), and performed extensive code tests and validations.
  (4) Proposed a set of cut-cell algorithms and develop the corresponding Fortran 90 program to handle the automatic mesh generation for DSMC simulation with very complex geometries (the developed cut-cell code has been adapted in the NASA DAC code).

(5) Conducted Nano-scale low speed flow simulations of aerosol particles and aggregates with complex geometries, using the developed DSMC code and cut-cell algorithms for aerosol aggregates drag prediction.

(6) Modular implementation of the existing DSMC rotational, vibrational and dissociation models for hypersonic chemically reacting flow simulations; conducted consistent evaluation and comparison of the existing DSMC models in simulating the hypersonic nonequilibrium flows.

(7) Proposed a modified inelastic collision selection procedure in DSMC method, to accurately simulate the internal energy exchange processes of gas mixtures using the phenomenological models.

- **Undergraduate Course Design and Senior Design**
  School of Aeronautical Science and Engineering, Beijing University of Aeronautics and Astronautics September 2006–July 2007

(1) Studied the unsteady flow filed around cylinder at low Reynolds numbers, by solving the incompressible Navier-Stokes equations using the pseudo-compressibility method.

(2) Investigated the overlap grid and moving grid techniques, and its application to the numerical simulation of the drag and energy consumption of fish locomotion, using the incompressible Navier-Stokes equations.

Publications

Journal Articles

1. **C. Zhang**, P. Valentini, and T. E. Schwartzentruber, Nonequilibrium-Direction-Dependent Rotational Energy Model for use in Continuum and Stochastic Molecular Simulation, *AIAA Journal*, 25(3), 604-617, 2014.
2. P. Valentini, P. Norman, **C. Zhang**, and T. E. Schwartzentruber, Rovibrational coupling in molecular nitrogen at high temperature: An atomic-level study, *Physics of Fluids*, 26(5), 2014
3. **C. Zhang** and T. E. Schwartzentruber, Inelastic Collision Selection Procedures for Direct Simulation Monte Carlo Calculations of Gas Mixtures, *Physics of Fluids*, 25(10), 106105, 2013.
4. P. Valentini, P. A. Tump, **C. Zhang**, and T. E. Schwartzentruber, Molecular Dynamics Simulations of Shock Waves in Mixtures of Noble Gases, *Journal of Thermophysics and Heat Transfer*, 27(2), 226–234, 2013.
5. **C. Zhang**, T. Thajudeen, C. Larriba, T. E. Schwartzentruber, and C. J. Hogan Jr., Determination of the Scalar Friction Factor for Non-spherical Particles and Aggregates Across the Entire Knudsen Number Range by Direct Simulation Monte Carlo (DSMC), *Aerosol Science and Technology,* 46(10), 1065–1078, 2012.
6. **C. Zhang** and T. E. Schwartzentruber, Robust Cut-cell Algorithms for DSMC Implementations Employing Multi-level Cartesian Grids, *Computers & Fluids*, 69, 122–135, 2012.
7. P. Valentini, **C. Zhang**, and T. E. Schwartzentruber, Molecular Dynamics Simulation of Rotational Relaxation in Nitrogen: Implications for Rotational Collision Number Models, *Physics of Fluids*, 24, 106101, 2012.
8. D. Gao, **C. Zhang**, and T. E. Schwartzentruber, Particle Simulations of Planetary Probe Flows Employing Automated Mesh Refinement, *Journal of Spacecraft and Rockets*, 48(3), 397–405, May-June 2011.

Journal Articles under Review / in Preparation

1. **C. Zhang** and T. E. Schwartzentruber, State-to-state Collision Models in Direct Simulation Monte Carlo: Consistent Implementations and Implications for Existing Phenomenological Models, *to be submitted to Journal of Computational Physics.*

Archived Conference Proceedings and Presentations (full paper)

1. **C. Zhang**, and T. E. Schwartzentruber, Consistent Implementation of State-to-state Collision Models for Direct Simulation Monte Carlo, AIAA Paper 2014-0866, *presented at the 52nd AIAA Aerospace Sciences Meeting*, National Harbor, MD, Jan. 2014.
2. P. Valentini, P. E. Norman, **C. Zhang**, and T. E. Schwartzentruber, Analysis of Rovibrational Relaxation in Nitrogen via Direct Atomic Simulation, AIAA Paper 2014-1079, *presented at the 52nd AIAA Aerospace Sciences Meeting*, National Harbor, MD, Jan. 2014.
3. **C. Zhang**, P. Valentini, and T. E. Schwartzentruber, A Nonequilibrium-Direction-Dependent Rotational Energy Model for Use in Continuum and Stochastic Molecular Simulation, AIAA Paper 2013-1202, *presented at the 51st AIAA Aerospace Sciences Meeting*, Grapevine, TX, Jan. 2013.

4. P. Valentini, **C. Zhang**, and T. E. Schwartzentruber, A Directional Rotational Relaxation Model for Nitrogen using Molecular Dynamics Simulation, AIP Conf. Proc. 1501, pp. 519–526, *28th International Symposium on Rarefied Gas Dynamics*, July 2012.
5. **C. Zhang** and T. E. Schwartzentruber, Numerical Assessment of Vibration and Dissociation Models in DSMC for Hypersonic Stagnation Line Flows, AIAA Paper 2012-2992, *presented at the 43rd AIAA Thermophysics Conference*, New Orleans, LA, June 2012.
6. P. Valentini, **C. Zhang**, and T. E. Schwartzentruber, Investigation of Rotational Relaxation in Nitrogen via Molecular Dynamics Simulation, AIAA Paper 2012-2995, *presented at the 43rd AIAA Thermophysics Conference*, New Orleans, LA, June 2012.
7. P. Valentini, P. A. Tump, **C. Zhang**, and T. E. Schwartzentruber, Molecular Dynamics Simulations of Normal Shock Waves in Dilute Gas Mixtures, AIAA Paper 2012-0225, *presented at the 50th AIAA Aerospace Sciences Meeting*, Nashville, TN, Jan. 2012.
8. **C. Zhang** and T. E. Schwartzentruber, Robust Cut-cell Algorithms for DSMC Implementation Employing Multi-level Cartesian Grids, AIAA Paper 2011-3314, *presented at the 42nd AIAA Thermophysics Conference*, Honolulu, HI, June 2011.
9. D. Gao, **C. Zhang**, and T. E. Schwartzentruber, A Three-Level Cartesian Geometry-Based Implementation of the DSMC Method, AIAA Paper 2010-0450, *presented at the 48th AIAA Aerospace Sciences Meeting*, Orlando, FL, Jan. 2010.

Conference Abstracts, Posters and Presentations

1. **C. Zhang** and T. E. Schwartzentruber, Consistent Implementation of State-to-state Collision Models for DSMC, *Direct Simulation Monte Carlo: Theory, Methods & Applications*, Santa Fe, NM, Oct. 2013. (Abstract & Presentation)
2. S. Poovathingal, **C. Zhang**, P. Norman, P. Valentini, I. Nompelis, and T. E. Schwartzentruber, Molecular Simulation of Hypersonic Flows, *10th International Planetary Probe Workshop*, San Jose, CA, June 2013. (Poster)
3. **C. Zhang** and T. E. Schwartzentruber, Molecular Fluid Dynamics for Non-continuum Engineering Problems, *2013 Doctoral Research Showcase*, University of Minnesota, Minneapolis, MN, April 9th, 2013. (Poster)
4. **C. Zhang**, T. Thajudeen, C. Larriba, T. E. Schwartzentruber, and C. J. Hogan Jr., Direct Simulation Monte Carlo (DSMC) Calculation of the Low Reynolds Number Drag on Aerosol Aggregates, *presented at the AAAR 31st Annual Conference*, Minneapolis, MN, Oct. 2012. (Abstract & Presentation)
5. C. J. Hogan, T. Thajudeen, **C. Zhang**, C. Larriba, and T. E. Schwartzentruber, The Friction Factor and Collision Kernel for Aggregates in the Mass and Momentum Transition Regimes, *2012 European Aerosol Conference*, Granada, Spain, September 2nd-7th, 2012. (Abstract)
6. D. Gao, **C. Zhang**, and T. E. Schwartzentruber, Molecular Gas Dynamics Simulation of Hypersonic Flow, *Minnesota Supercomputing Institute 25th Anniversary Research Exhibition*, University of Minnesota, Minneapolis, MN, April 2010. (Poster)
7. **C. Zhang**, D. Gao, and T. E. Schwartzentruber, Data Structures and Adaptive Mesh Refinement for a 3-Level Embedded Cartesian Mesh DSMC Implementation, Bulletin of the American Physical Society, Volume 54, Number 19, *presented at the 62nd Annual Meeting of the APS Division of Fluid dynamics*, Minneapolis, MN, Nov. 2009. (Abstract & Presentation)
8. D. Gao, **C. Zhang**, and T. E. Schwartzentruber, Parallel Performance Optimization of the Direct Simulation Monte Carlo Method. Bulletin of the American Physical Society, Volume 54, Number 19, *presented at the 62nd Annual Meeting of the APS Division of Fluid dynamics*, Minneapolis, MN, Nov. 2009. (Abstract)
9. D. Gao, **C. Zhang**, and T. E. Schwartzentruber, A Three-level Cartesian Mesh Implementation of the DSMC Method with Adaptive Mesh Refinement, *Direct Simulation Monte Carlo: Theory, Methods & Applications*, Santa Fe, NM, Sept. 2009. (Abstract)

Honors and Awards

- Doctoral Dissertation Fellowship, Graduate School, University of Minnesota (in recognition of outstanding research work) 2012
- John & Jane Dunning Copper Fellowship, Department of Aerospace Engineering and Mechanics, University of Minnesota (for excellent performance in the Ph.D. Written Preliminary Exam) 2009
- "Renmin" Scholarship for Excellence in Academic Performance, Beijing University of Aeronautics and Astronautics, Beijing, China 2004, 2005, 2006

- Freshmen Scholarship, Beijing University of Aeronautics and Astronautics, Beijing, China 2003

Coursework (all graduate-level courses)

Aerospace Engineering and Mechanics Department:

- Fluid Mechanics I, II, III
- Molecular Gas Dynamics
- Computational Fluid Mechanics
- Computational Methods in Fluid Mechanics
- Finite Volume Methods in Computational Fluid Dynamics
- Continuum Mechanics
- Fracture Mechanics
- Multiscale Methods for Bridging Length and Time Scales

Chemistry Department:

- Quantum Mechanics
- Thermodynamics, Statistical Mechanics, and Reaction Dynamics I, II

Mathematics Department:

- Numerical Analysis and Scientific Computing
- Numerical Analysis of Differential Equations I, II

Skills

- Programming: Fortran, C, C++, Java, Python
- Software: Tecplot, Gridgen, AutoCAD, CATIA, SolidWorks, Mathematica, Matlab
- Operating Systems: GNU/Linux, Mac OS X, Windows