Chonglin Zhang

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Research Interests

- Rarefied gas dynamics, Kinetic theory of gases
- Direct simulation Monte Carlo (DSMC) stochastic particle method
- Hypersonic flow, Aerothermodynamics
- Computational Fluid Dynamics (CFD), High Performance Computing
- Micro/nano-scale flow

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 and Industry Experience

- **Project Engineer** July 2015–
  Simerics, Inc.
  - Working on various CFD simulation projects, including fluid machinery devices (positive displacement pumps, centrifugal pumps, compressors, fluid valves etc.), external aerodynamics, automotive engine cooling system; developing method and simulation capability in these areas, involving moving and deforming mesh, single phase flow, cavitation, multi-phase flow, phase-change, boiling heat transfer, conjugate heat transfer etc.
- **Research Fellow** March 2015–July 2015
  Department of Mechanical Engineering, University of Michigan
  - Modeling soot precursor molecules formation/nucleation based on molecular simulation; Developing physical collision rate model for soot/nano-particle growth in combustion.
- **Postdoctoral Research Associate** September 2013–February 2015
  Department of Aerospace Engineering and Mechanics, University of Minnesota
  - State-to-state collision model development in the DSMC method using computational chemistry results, to better model hypersonic nonequilibrium flow; reduced order thermo-chemical models informed from state-to-state model, for DSMC and CFD simulation of chemically reacting flows.
- **Graduate Research Assistant** January 2009–August 2013
  Department of Aerospace Engineering and Mechanics, University of Minnesota

(1) Developed a 3D direct simulation Monte Carlo (DSMC) code for hypersonic aerodynamics, aerothermodynamics, as well as micro/nano scale flow modeling and simulation; main author of the serial version, co-author of the parallel version code.

(2) Author of an adaptive mesh refinement (AMR) algorithms/module for automatic mesh re-generation in the Cartesian grid DSMC code; author of a set of cut-cell algorithms and code module to handle the automatic mesh generation for DSMC simulation with very complex geometries (the code is around 5500 lines, has been adapted by NASA in the DAC code).

(3) Developed a set of DSMC internal energy (rotational and vibrational energy) relaxation, chemical reaction and ionization models for hypersonic chemically reacting flow simulations (the code module is around 13000 lines, has been adapted by NASA in the DAC code).

(4) 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.

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

(6) 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.

(7) Conducted Nano-scale low speed flow simulations of aerosol particles and aggregates with complex geometries, using the developed DSMC code and cut-cell algorithms; obtained transition regime drag coefficient for aerosol aggregates of various shapes.

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

  (1) Studied the unsteady flow filed around cylinder at low Reynolds numbers, by solving the incompressible Navier-Stokes equations with the pseudo-compressibility method.
  (2) Studied the drag and energy consumption of fish locomotion, based on computational fluid dynamics coupled with overlap and moving grid techniques.

Publications

Journal Articles

1. C. Srinivasan, **C. Zhang**, H. Gao, D. Wang, J. Slike, Modeling of Phase Change within a Wax Element Thermostat Embedded in an Automotive Cooling System, *SAE International Journal of Engine*, 10(2), 181-195, 2017.
2. **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.
3. 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
4. **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.
5. 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.
6. **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.
7. **C. Zhang** and T. E. Schwartzentruber, Robust Cut-cell Algorithms for DSMC Implementations Employing Multi-level Cartesian Grids, *Computers & Fluids*, 69, 122–135, 2012.
8. 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.
9. 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.

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

Graduate-level courses:

- Fluid Mechanics I, II, III
- Molecular Gas Dynamics
- Computational Fluid Mechanics
- Hypersonic Aerodynamics
- Computational Methods in Fluid Mechanics
- Finite Volume Methods in Computational Fluid Dynamics
- Continuum Mechanics
- Fracture Mechanics
- Multiscale Methods for Bridging Length and Time Scales
- Quantum Mechanics
- Thermodynamics, Statistical Mechanics, and Reaction Dynamics I, II
- Numerical Analysis and Scientific Computing
- Numerical Analysis of Differential Equations I, II

Undergraduate-level courses:

- Theoretical Mechanics (Statics and Dynamics) I, II
- Mechanics of Materials I, II
- Engineering Thermodynamics
- Mathematical Modeling
- Applied Mechanics (Elasticity)
- Aerodynamics I, II
- Heat Transfer
- Viscous Fluid Mechanics
- Computational Fluid Dynamics
- Mechanical Design I, II, III
- Structural Mechanics
- Mechanics of Aerospace Structure
- Automatic Control
- Aircraft Flight Mechanics (Flight Dynamics)

Professional Services

- Journal Reviewer: Journal of Fluid Mechanics, Computers and Fluids, Journal of Spacecraft and Rockets
- Conference Reviewer: AIAA Aviation Conference, ASME IMECE conference, SAE World Congress Experience