

# E. Alec Johnson

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**Research:** plasma modeling, fast magnetic reconnection in collisionless space plasmas, positivity-preserving discontinuous Galerkin methods, 10-moment two-fluid plasma models

## Education

- Ph.D. Mathematics (computational focus), UW-Madison, Dec 24, 2011 (dissertation deposited September 1, 2011).
- Budapest Semesters in Mathematics, spring 2003.
- B.A. Mathematics, St. Olaf College, 1997, *summa cum laude*.

## Employment History

- **Teaching Assistant**, UW-Madison (2003 to 2011)

semester	course	lecturer
2011 (spring)	Math 112 (college algebra)	me (under Mike Schroeder)
2010 (fall)	Math 320 (linear algebra, ODEs)	Dongming Wei
2010 (fall)	Math 320 (linear algebra, ODEs)	Jeff Viaclovsky
2010 (spring)	Math 210 (finite math)	Paul Terwilliger
2009 (fall)	Calculus 234 (third semester)	Amir Assadi
2009 (spring)	Calculus 234 (third semester)	Amir Assadi
2008 (fall)	Calculus 234 (third semester)	Andreas Seeger
2007 (fall)	Math 114 (algebra)	Adriana Nenciu
2007 (spring)	Math 217 WES (algebra and calculus)	Ke Zhu
2006 (fall)	Math 171 WES (algebra and calculus)	Han Peters
2006 (spring)	Calculus 222 (second semester)	Concetta Gomez
2005 (fall)	Math 171 (algebra and calculus)	Concetta Gomez
2005 (spring)	Math 319 (differential equations)	Marshall Slemrod
2004 (fall)	Calculus 234 (third semester)	Robert Wilson
2004 (spring)	Calculus 222 (second semester)	Arnold Miller
2003 (fall)	Calculus 221 (first semester)	Paul Milewski

(Note: WES = Wisconsin Emerging Scholars)

- **High School Teacher**, Trinity School at River Ridge, Bloomington, MN (2001-2002)

Taught Greek, algebra, precalculus, physics, and a senior science colloquium. Trinity School is a unique and passionate community of learners in which I engaged faculty and students in many spontaneous and formal discussions about math, physics, philosophy, theology, linguistics, music, art,

poetry, anthropology, history, and literature.

- **Software Developer**, CES International, Plymouth, MN (1998-2001)  
Responsible for development of key application used to instruct electrical device operations to work crews and automated systems. Analyzed requirements, designed, specified tasks, implemented, documented, fixed bugs, and reviewed code. Assigned to mentor other programmers.
- **High School Teacher**, Walnut Ridge Baptist Academy, Waterloo, IA (1997-1998)  
Taught physics, calculus, precalculus, geometry, and algebra.
- **Summer Research**, Center for Geophysical Studies of Ice and Climate, St. Olaf College (1994-97)  
Studied glacial and Antarctic ice flow using satellite images and seismic radar profiles. Worked on three basic tasks, all requiring analysis and software implementation: (1) migrating (focusing) seismic profiles (an inverse transform problem), (2) generating velocity fields of ice flow from repeat satellite images, and (3) mosaicing satellite images. Independently studied Fourier and inverse methods for integral transforms. Implemented 3-dimensional frequency-domain-based wavefield migration algorithm. Wrote a set of documents on migration giving pedagogical background and systematically analyzing errors incurred by the hierarchy of modeling assumptions.

### Additional Experience

- **Copy editor**, *Communications in Mathematical Sciences*, edited by Shi Jin (June 2007 – May 2008)

**Software:** C++, C, Fortran 77/95, IDL, Matlab, Maple, UNIX, shell, perl, subversion, L<sup>A</sup>T<sub>E</sub>X

### Awards

- VIGRE Fellowship, UW-Madison, Summer 2010 (declined).
- VIGRE Fellowship, UW-Madison, Spring 2008.
- Wisconsin Space Grant Consortium Graduate Fellowships, 2006-07, 2007-08, 2008-09.

### Accomplishments

- Contributed to **DoGPack** (Discontinuous Galerkin Package, created by my advisor J.A. Rossmannith): restructured and modularized the core library and user interface; accelerated general execution speed of code by an order of magnitude.
- Planted a garden, summer 2009.
- Traveled around the world visiting educational and academic institutions and community centers in China, Thailand, India, Ethiopia, and Uganda, June 14 – Aug 18, 2010.

### Publications

- E.A. Johnson and J.A. Rossmannith, *Boundary Average Positivity Limiting*, in preparation.

- E.A. Johnson and J.A. Rossmannith, *Positivity limiting for ten-moment gas dynamics*, in preparation.
- E.A. Johnson, *Gaussian-Moment Relaxation Closures for Verifiable Numerical Simulation of Fast Magnetic Reconnection in Plasma*, PhD thesis, UW–Madison, 2011
- E.A. Johnson and J.A. Rossmannith, *Ten-moment two-fluid plasma model agrees well with PIC/Vlasov in GEM problem*, Series in Contemporary Applied Mathematics, Proceedings for Hyp2010, November 2010.
- E.A. Johnson and J.A. Rossmannith, *Simulation of Fast Magnetic Reconnection using a Two-Fluid Model of Collisionless Pair Plasma without Anomalous Resistivity*, Proceedings of the 18th Annual Wisconsin Space Conference, Wisconsin Space Grant Consortium, 2009.
- E.A. Johnson and J.A. Rossmannith, *Collisionless Magnetic Reconnection in a Five-Moment Two-Fluid Electron-Positron Plasma*, Proceedings of Symposia in Applied Mathematics, 12th International Conference on Hyperbolic Problems, 2008.
- E.A. Johnson and J.A. Rossmannith, *Discontinuous Galerkin Simulations of the Collisionless Five-moment and Ten-moment Two-fluid Plasma Models*, Proceedings of the 17th Annual Wisconsin Space Conference, Wisconsin Space Grant Consortium, 2008.
- E.A. Johnson, *Brio-Wu Shock Problem Computations for a Collisionless Two-fluid Plasma Model*, Proceedings of the 17th Annual Wisconsin Space Conference, Wisconsin Space Grant Consortium, 2007.
- E.A. Johnson, C.W. Dorsey, and R.W. Jacobel, *An Image-Derived Velocity for Ice Flow Near Siple Dome, West Antarctica*. EOS Transactions American Geophysical Union, 78 (46), p. F249, 1997.

## Posters

- *Gaussian-moment two-fluid MHD relaxation closure for sustained collisionless fast magnetic reconnection*, E. Alec Johnson and James Rossmannith, APS-DPP 53rd Annual Meeting, Salt Lake City, UT, November 16, 2011.
- *Pressure anisotropy in two-fluid simulations of magnetic reconnection*, E. Alec Johnson and James Rossmannith, APS-DPP 52nd Annual Meeting, Chicago, IL, November 8, 2010.
- *Null-point [two-dimensional] reconnection in fluid pair plasma without anomalous resistivity*, E. Alec Johnson and James Rossmannith, MR2009 (US–Japan Workshop on Magnetic Reconnection, held by the Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas), Madison, WI, October 5, 2009.
- *Simulation of fast magnetic reconnection*, E. Alec Johnson and James Rossmannith, SIAM AN08, San Diego, CA, July 2008.
- *Pattern recognition in Magnetoencephalography (MEG) data*, with Amir Assadi, Arash Bahrami, Alison Harris, Brenton McMenamin, and Ken Nakayama, presented at Annual CNS (Computational NeuroScience) Meeting, UW-Madison, 2005.

## Presentations

- *Boundary Integral Positivity Limiters*, Applied Graduate Participation Seminar, UW math department, October 17, 2011.
- *Fast magnetic reconnection with a ten-moment two-fluid plasma model*, dissertation defense, UW-Madison, September 23, 2011.
- *Plasma Modeling*, UW-Madison math department cookie seminar, November 30, 2010.
- *Simulation of Fast Magnetic Reconnection with a Ten-Moment Two-Fluid Model*, Hyp2010, Beijing, June 15, 2010.
- *What is multivariable calculus good for?*, Math Club (undergraduate), UW-Madison, December 14, 2009.
- *Levermore closure for the ten-moment heat flux*, Applied Math Graduate Participation Seminar, UW-Madison, September 30, 2009.
- *Fast Magnetic Reconnection in Fluid Models of (Pair) Plasma*, Postdoctoral Research Symposium, Argonne National Laboratories, September 10, 2009.
- *Fast Magnetic Reconnection in Fluid Models of Pair Plasma*, Wisconsin Space Conference, Milwaukee School of Engineering, August 2009.
- *Fast Magnetic Reconnection in Fluid Models of Pair Plasma*, SIAM Annual Meeting, Denver, Colorado, July 2009.
- *Magnetic reconnection in fluid models of pair plasma*, Plasma Theory Seminar, UW-Madison, June 2009.
- *Fast magnetic reconnection in isotropic pair plasma*, SIAM conference on Computational Science and Engineering, Miami, Florida, March 2009.
- *Special relativistic fluid dynamics*, Applied Math Student Seminar, UW-Madison, February 2009.
- *Discontinuous Galerkin methods for plasmas*, Applied Math Student Seminar, UW-Madison, September 2008.
- *Collisionless plasma simulation for space weather*, Wisconsin Space Conference, UW-Fox Valley, August 2008.
- *Multiscale simulation of waves in plasmas*, Hyp2008, University of Maryland, June 2008.
- *Combinatorial wardrobe*, Math Week, Madison East High School, May 2008.
- *Waves in plasmas*, Applied Math Student Seminar, UW-Madison, March 2008.
- *Computational continuum mechanics: what is it, why do I like it, and how can you learn it?*, High School Math Night, UW-Madison, December 2007.
- *The analogy between vorticity and magnetic field in MHD*, Applied Math Student Seminar, UW-Madison, October 2007.
- *Shock-Capturing Schemes for a Collisionless Two-Fluid Plasma Model*, presented at Sandia National Laboratories, August 2007.
- *A Fast Shock-Capturing Algorithm for a Two-Fluid Plasma Model*, Wisconsin Space Conference, UW-Superior, August 2007.
- *Derivation of the Boussinesq approximation*, Math 801 (geophysical fluid dynamics), UW-Madison, April 2007.
- *Fundamental equations of plasmas*, Applied Math Student Seminar, UW-Madison, March 2007.
- *A kinetic derivation of plasma laws*, Applied Math Student Seminar, UW-Madison, November 2006.

- *Proofs of the Fundamental Theorem of Numerical Analysis*, Applied Math Student Seminar, UW-Madison, February 2006.

**Research notes** (<http://www.math.wisc.edu/~ejohnson/summaries/plasma.html>)

- *Derivations of eigenstructure for 10-moment and MHD plasma models.*
- *Descriptions of numerical methods (diffusive DG, constrained transport)*
- **10-moment (and 5-moment) closure.**
- *Derivations of balance laws for moments (including current balance, i.e. Ohm's law).*

**Pedagogical notes** (<http://www.math.wisc.edu/~ejohnson/summaries>)

- **Notes on multivariable calculus** (a concise text).
- *Basic numerics (Lax equivalence theorem, finite volume, discontinuous Galerkin).*
- *Thermodynamics (convex entropy, symmetric hyperbolic form).*
- *Fluid mechanics (Navier-Stokes, Boussinesq approximation, potential vorticity).*

**Qualifying examinations**

- fall 2005: passed Analysis qualifier (86%, highest score was 87%).
- fall 2004: passed Numerical Analysis and Applied Mathematics qualifiers.

**Course work (graduate-level)**

- Numerical Analysis: introductory sequence and numerical functional analysis.
- Applied Math: introductory sequence; fluid mechanics (courses in turbulence, waves, and Boussinesq approximation), elasticity, stochastic models in biology.
- Analysis: measure theory, functional analysis, dynamical systems, and partial differential equations.
- Geometry: differential manifolds.
- Fundamentals: introductory courses in algebra and logic.