Gregory W. Hammett

Princeton Plasma Physics Laboratory
Forrestal Campus, Princeton University
P.O. Box 451
Princeton, NJ 08543

hammett@princeton.edu
hammett@pppl.gov
https://w3.pppl.gov/~hammett
phone: +1-609-243-2495

EDUCATION:

1986 Ph.D. Princeton University, Astrophysical Sciences, Program in Plasma Physics
1980 B.A. Harvard University, Physics
1976 Baldwin County High School, Milledgeville, Georgia

Appointments:

2013- Distinguished Research Fellow, Princeton Plasma Physics Laboratory
2013 Trinity Term, Visiting Research Fellow, Merton College, Oxford
2013 Spring, Director of Graduate Studies, Princeton Program in Plasma Physics
2010 Summer, Visiting Fellow, Isaac Newton Inst. for Mathematical Sciences, Cambridge
2005 Spring, Long Term Participant, Kavli Inst. for Theoretical Physics, Santa Barbara
2004 Fall Miller Visiting Research Professor, Astronomy Dept., U. California Berkeley
2001-2002 Visiting Scientist, Department of Physics, Imperial College, London
1995- Lecturer, Program in Plasma Physics, Princeton University
(Lecturer with Rank of Professor since 2001)
1993- Research Physicist, Theory Division, Princeton Plasma Physics Laboratory
1987-1991 Visiting Scientist, Joint European Torus, Oxfordshire, England
1986-1993 Research Physicist, TFTR Tokamak, Princeton Plasma Physics Laboratory
1976-1979 Summer Jobs with Grumman Aerospace, in factories and then research

RESEARCH SUMMARY:

Greg Hammett is a Distinguished Research Fellow and Principal Research Physicist at the Princeton Plasma Physics Laboratory (PPPL), and a Lecturer with Rank of Professor in the Princeton University Program in Plasma Physics, Department of Astrophysical Sciences. He is on the associated faculty of the Princeton Program in Applied and Computational Mathematics. He received a DOE Distinguished Scientist award in 2021 for "leading the development of the quantitative theory and simulation of plasma turbulence in fusion and astrophysics, and for educating and mentoring a diverse group of graduate students and early career researchers." He was selected as a fellow of the American Physical Society in 1997. PPPL does research in plasma physics and fusion energy, which has the potential to be an attractive new energy source. Dr. Hammett specializes in computational and theoretical studies of the complex physics of plasma turbulence. He and collaborators are working on supercomputer simulations of 5-dimensional gyrokinetic plasma turbulence in fusion devices, and are studying methods to reduce turbulent heat losses, which could lead to a more economical fusion power plant. Most recently, they have been working on a code using novel versions of Discontinuous Galerkin algorithms for the challenging edge region of tokamaks. Their code was the first to be able to include magnetic fluctuations in turbulence simulations of a tokamak edge region. His work on fluid models of Landau-damping (which extends fluid equations

to the long-mean-free-path regime where traditional closure approximations break down) has been cited in over 400 published papers, finding application to diverse fields such as Alfvén turbulence in space physics, Langmuir turbulence in the ionosphere, plasma processing of semiconductors, MHD instabilities, and laser-plasma processes, as well as his own specialty of plasma turbulence in fusion devices. He has done some research in plasma astrophysics, such as kinetic effects on turbulence driven by the magnetorotational instability in accretion disks around black holes and other objects. He has supervised 12 Ph.D. students.

Selected Publications:

Co-author of over 180 papers in scientific journals and proceedings of national and international conferences, including 7 listed in *Selected Highly Cited Papers from 50 Years of Plasma Physics*, a special publication of the journal *Physics of Plasmas*. More papers and talks online at w3.pppl.gov/∼hammett/papers.

"Electromagnetic full-f gyrokinetics in the tokamak edge with discontinuous Galerkin methods", N. R. Mandell, A. Hakim, G. W. Hammett, M. Francisquez, J. Plasma Phys. 86, 905860109 (2020). https://doi.org/10.1017/S0022377820000070

"Continuum electromagnetic gyrokinetic simulations of turbulence in the tokamak scrape-off layer and laboratory devices", Ammar H. Hakim, Noah R. Mandell, T. N. Bernard, M. Francisquez, G. W. Hammett, and E. L. Shi, Phy. Plasmas 27, 042304 (2020) (APS-DPP invited talk paper.) https://doi.org/10.1063/1.5141157

"Fluid and gyrokinetic turbulence in open field-line, helical plasmas", M. Francisquez, T. N. Bernard, B. Zhu, A. Hakim, B. N. Rogers, and G. W. Hammett , Physics of Plasmas 27, 082301 (2020) https://doi.org/10.1063/5.0005333

"Gyrokinetic continuum simulations of plasma turbulence in the Texas Helimak", Bernard, T. N.; Shi, E. L.; Gentle, K. W.; Hakim, A.; Hammett, G. W.; Stoltzfus-Dueck, T.; Taylor, E. I., Physics of Plasmas, 26, 042301 (2019) https://doi.org/10.1063/1.5085457

"Full-f gyrokinetic simulation of turbulence in a helical open-field-line plasma", Shi, E. L.; Hammett, G. W.; Stoltzfus-Dueck, T.; Hakim, A., Physics of Plasmas 26, 012307 (2019) https://doi.org/10.1063/1.5074179

"Gyrokinetic continuum simulation of turbulence in a straight open-field-line plasma", E. L. Shi, G. W. Hammett, T. Stoltzfus-Dueck, A. Hakim, J. of Plasma Physics 83 (2017) 905830304. (Editors selected this as a Featured Article so it is free to download, https://doi.org/10.1017/S002237781700037X.)

"Phase mixing versus nonlinear advection in drift-kinetic plasma turbulence", A. A. Schekochihin, J. T. Parker, E. G. Highcock, P. J. Dellar, W. Dorland, G. W. Hammett, J. Plasma Phys. 82, 905820212 (2016).

"Multiscale Nature of the Dissipation Range in Gyrokinetic Simulations of Alfvenic Turbulence", D. Told, F. Jenko, J. M. TenBarge, G. G. Howes, and G. W. Hammett Phys. Rev. Lett. 115, 025003 (2015)

"Intrinsic momentum transport in up-down asymmetric tokamaks", Justin Ball, Felix I. Parra, Michael Barnes, William Dorland, Gregory W. Hammett, Paulo Rodrigues, Nuno F. Loureiro, Plasma Phys. Control. Fusion 56 (2014), 095014

"Applications of large eddy simulation methods to gyrokinetic turbulence", A. Bañón Navarro, B. Teaca, F. Jenko, G. W. Hammett, T. Happel and ASDEX Upgrade Team, Phys. Plasmas 21, 032304 (2014).

"Report of the Study Group GK2 on Momentum Transport in Gyrokinetics", J. A. Krommes and G. W. Hammett, Technical Report PPPL-4945, October, 2013.
https://bp.pppl.gov/pub_report/2014/PPPL-4945-abs.html

"Positivity Preservation and Advection Algorithms With Applications to Edge Plasma Turbulence", J. L. Peterson and G. W. Hammett, SIAM J. Sci. Computing 35, B576 (2013)

"Comparing linear ion-temperature-gradient-driven mode stability of the National Compact Stellarator Experiment and a shaped tokamak" J. A. Baumgaertel, G. W. Hammett, and D. R. Mikkelsen, Phys. Plasmas 20, 022305 (2013).

"Suppressing Electron Turbulence and Triggering Internal Transport Barriers with Reversed Magnetic Shear in the National Spherical Torus Experiment", J. L. Peterson, R. Bell, J. Candy, W. Guttenfelder, G. W. Hammett, S. M. Kaye, B. LeBlanc, D. R. Mikkelsen, D. R. Smith, and H. Y. Yuh, Phys. Plasmas 19, 056120 (2012). (2011 APS-DPP Invited Talk.)

"Gyrokinetic statistical absolute equilibrium and turbulence", Jian-Zhou Zhu, G. W. Hammett, Phys. Plasmas **17**, 122307 (2010)

"Direct multiscale coupling of a transport code to gyrokinetic turbulence codes", M. Barnes, I. G. Abel, W. Dorland, T. Goerler, G. W. Hammett, F. Jenko, Phys. Plasmas **17**, 056109 (2010)

"Kinetic Simulations of Magnetized Turbulence in Astrophysical Plasmas", G. G. Howes, W. Dorland, S. C. Cowley, G. W. Hammett, E. Quataert, A. A. Schekochihin, T. Tatsuno, Phys. Rev. Lett. 100, 065004 (2008)

"On 1D diffusion problems with a gradient-dependent diffusion coefficient," S.C. Jardin, G. Bateman, G.W. Hammett, L.P. Ku, J. Comp. Phys. **227**, 8769 (2008)

"An Iterative Semi-Implicit Scheme with Robust Damping", N.F. Loureiro, G.W. Hammett, J. Comp. Phys. **227**, 4518 (2008)

"Preserving monotonicity in anisotropic diffusion", P. Sharma, G.W. Hammett, J. Comp. Phys. **227**, 123 (2007) https://doi.org/10.1016/j.jcp.2007.07.026

"Electron Heating in Hot Accretion Flows," P. Sharma, E. Quataert, G.W. Hammett, J.M. Stone, ApJ 667, 714 (2007)

"Shearing Box Simulations of the MRI in a Collisionless Plasma", P. Sharma, G.W. Hammett, E. Quataert, and J.M. Stone, Astrophys. J. 637, 952 (2006)

"Discrete Particle Noise in PIC Simulations of ETG Turbulence," W. M. Nevins, G. W. Hammett, A. M. Dimits, W. Dorland & D. E. Shumaker, Phys. Plasmas 12, 122305 (2005)

"Comparisons and physics basis of tokamak transport models and turbulence simulations," A.M. Dimits, G. Bateman, M.A. Beer, et al., Phys. Plasmas **7**, 969 (2000).

"Landau fluid models of collisionless magnetohydrodynamics," P.B. Snyder, G.W. Hammett, and W. Dorland, Phys. Plasmas 4, 3974 (1997)

"A gyro-Landau-fluid transport model," R.E. Waltz, G.M. Staebler, W. Dorland, G.W. Hammett, M. Kotschenreuther, J.A. Konings, Phys. Plasmas **4**, 2482 (1997)

"Roles of Electric Field Shear and Shafranov Shift in Sustaining High Confinement in Enhanced Reversed Shear Plasmas on the TFTR Tokamak", E. J. Synakowski, S. H. Batha, M. A. Beer, Phys. Rev. Lett. **78**, 2972 (1997) https://doi.org/10.1103/PhysRevLett.78.2972

"Turbulent Fluctuations in TFTR Configurations with Reversed Magnetic Shear", E. Mazzucato, S. H. Batha, M. A. Beer, et al., Phys. Rev. Lett., **77**, 3145 (1996).

"Why be a Scientist," in *Finding God at Harvard*, ed. Kelly Monroe, (Zondervan, 1996).

"Quantitative predictions of tokamak energy confinement from first-principles simulations with kinetic effects", M. Kotschenreuther, W. Dorland, M.A. Beer, and G.W. Hammett, Phys. Plasmas **2**, 2381 (1995).

"Field-aligned coordinates for nonlinear simulations of tokamak turbulence", M. A. Beer, S. C. Cowley, and G. W. Hammett , Physics of Plasmas 2 , 2687-2700 (1995)
https://doi.org/10.1063/1.871232

"Fusion power production from TFTR plasmas fueled with deuterium and tritium", J.D. Strachan, H. Adler, P. Alling, et. al, Phys. Rev. Lett. **72**, 3526 (1994)
"Confinement and heating of a deuterium-tritium plasma", R. J. Hawryluk, 'H. Adler, 'P. Ailing, et al., Phys. Rev. Lett. **72**, 3530 (1994)

"Developments in the Gyrofluid Approach to Tokamak Turbulence Simulations" G.W. Hammett, M.A. Beer, W. Dorland, S.C. Cowley, and S.A. Smith, Plasma Phys. Control. Fusion 35, 973 (1993)

"Fluid Models of Phase Mixing, Landau Damping, and Nonlinear Gyrokinetic Dynamics," G. W. Hammett, W. Dorland and F. W. Perkins, Phys. Fluids **B4**, 2052 (1992)

"Fluid Moment Models for Landau Damping with Application to the Ion-Temperature-Gradient Instability," G.W. Hammett & F.W. Perkins, Phys. Rev. Lett. 64 (1990) 3019

"Ion radial transport induced by ICRF waves in tokamaks", Liu Chen, J. Vaclavik, and G.W. Hammett, Nucl. Fusion **28**, 389 (1988)

"Fast Ion Studies of Ion Cyclotron Heating in the PLT Tokamak", G.W. Hammett, Ph.D. Thesis, University Microfilms International No. GAX86-12694, Princeton University (1986).

Princeton Ph.D. Theses supervised:

Willam D. Dorland, "Gyrofluid Models of Plasma Turbulence" (1993)

Michael A. Beer, "Gyrofluid Models of Turbulent Transport in Tokamaks" (1994, APS best plasma physics thesis award)

Stephen A. Smith, "Dissipative Closures for Statistical Moments, Fluid Moments, and Subgrid Scales in Plasma Turbulence" (1997)

Phillip B. Snyder, "Gyrofluid Theory and Simulation of Electromagnetic Turbulence and Transport in Tokamak Plasmas" (1999)

Emily A. Belli, "Studies of Numerical Algorithms for Gyrokinetics and the Effects of Shaping on Plasma Turbulence" (2006)

Prateek Sharma, "Kinetic Effects on Turbulence Driven by the Magnetorotational Instability in Black Hole Accretion" (2006)

Jayson Luc Peterson, "Relating Gyrokinetic Electron Turbulence to Plasma Confinement in the National Spherical Torus Experiment" (2011)

Jessica A. Baumgaertel, "Simulating the Effects of Stellarator Geometry on Gyrokinetic Drift-Wave Turbulence" (2012)

Erik M. Granstedt, "The Low-Recyling Lithium Boundary and Implications for Plasma Transport" (2013)

Eric L. Shi, "Gyrokinetic Continuum Simulation of Turbulence in Open-Field-Line Plasmas" (2017)

Noah R. Mandell, "Magnetic Fluctuations in Gyrokinetic Simulations of Tokamak Scrape-Off Layer Turbulence" (2021)

Visiting Ph.D. and Master's Theses supervised:

Nadine Kremer (Ulm University Diploma thesis), "Analytic and Numerical Study of Current-Driven Drift Waves and Microturbulence in Fusion Energy Devices" (2012)

Tess A. Bernard (U. Texas Ph.D. thesis), "Discontinuous Galerkin Modeling of Plasma Turbulence in a Simple Magnetized Torus" (2019)

Graduate courses taught:

1995- Lecturer (with Rank of Professor since 2001), Program in Plasma Physics, Department of Astrophysical Sciences, Princeton University.

1995-2000, 2002-2005 Co-taught "General Plasma Physics I", the introduction to plasma physics for first year graduate students, with Prof. Nat Fisch.

2001, 2007-2009, 2016, 2022 Taught "Irreversible Processes in Plasmas", an advanced graduate course (2001 with Prof. John Krommes, 2002 with Prof. Ilya Dodin).

2010 Co-led the graduate "Seminar in Theoretical Astrophysics: Plasma Astrophysics" with Prof. Jim Stone.

2020 (S), 2021 (S) Taught graduate course APC 523 / AST 523 / MAE 507, "Numerical Algorithms for Scientific Computing".

2011 (F), 2014 (S), 2018 (S), 2020 (F), 2022 (F) Taught AST559 "Turbulence and Nonlinear Processes in Fluids and Plasmas", an advanced graduate course. (cross listed in the Program in Applied and Computational Mathematics)

2015 (S), 2017 (S) , 2019 (S), 2023 (2) Co-taught graduate course AST560 "Computational Methods in Plasma Physics", with Prof. Hong Qin.

Selected Lectures and Seminars:

2000 Selected as one of 6 "Distinguished Lecturers" for the American Physical Society Division of Plasma Physics, a program to provide speakers for university symposiums/colloquiums on exciting recent advances in plasma physics.

2001 Invited lecturer at the Autumn College on Plasma Physics, held at the Abdus Salam International Centre for Theoretical Physics (Trieste, Italy). Co-taught a computational physics workshop with Prof. Bill Dorland of Imperial College.

1994- Frequent lecturer in the 1 week Summer School for the National Undergraduate Fellowships In Fusion Energy, Princeton University, and from 2015, the 1 week SULI Introductory Course in Plasma Physics in Princeton, for the DOE Science Undergraduate Laboratory Internship program.

Other invited lectures include: MIT, Columbia University; New York University; U. Maryland; University of Florida; Florida A&M; Clark Atlanta University; U. Texas at Austin; University of Wisconsin; Lawrence Berkeley National Laboratory; Los Alamos National Laboratory; Summer School for National Undergraduate Fellows in Fusion Energy, Princeton; University of Durham, UK; Joint European Torus, Culham Centre for Fusion Energy, United Kingdom Atomic Energy Authority; Kavli Institute for Theoretical Physics at U.C. Santa Barbara; Oak Ridge National Laboratory; The Fields Institute for Research in Mathematical Sciences, Toronto; University of Chicago; University of Ottawa; Wolfgang Pauli Institute, Vienna; UCLA; University of Florida; University of New Hampshire; Centre International de Rencontres Mathematiques, Marseille; Max Planck Institute for the Physics of Complex Systems, Dresden, Germany; Isaac Newton Inst. for Mathematical Sciences, Cambridge; Imperial College; University of Oxford; Institute for Pure and Applied Mathematics, UCLA.

Guest Teacher, The Father's Heart Urban Prep School, Trenton, NJ (1995).

Selected Invited Talks (some published):

More talks and presentations available online at `w3.pppl.gov/~hammett/talks`

"Progress in 5-Dimensional Plasma Turbulence Simulations in Fusion Energy Devices," G.W. Hammett, invited review talk, American Physical Society April Meeting, 2007.

"Current Status of Fusion Energy Research & Related Plasma Turbulence Studies," G.W. Hammett, Kavli Institute for Theoretical Physics, U.C. Santa Barbara, May 19, 2005.

"Particle Noise-Induced Diffusion & Its Effect on ETG Simulations," G.W. Hammett, W.M. Nevins, A.M. Dimits, 2005 International Sherwood Fusion Theory Conference, Lake Tahoe, Nevada, April 11-13, 2005.

"Fluid models of kinetic effects", invited speaker, Workshop on Kinetic Theory, Fields Institute, Toronto, March, 2004.

"Turbulence and Transport in Burning Plasmas", invited speaker, AAAS Annual Meeting, Seattle, Feb. 2004.

"Theory Based Models of Turbulence and Anomalous Transport," G.W. Hammett, invited talk, American Physical Society (APS) Centennial Meeting (Atlanta, 1999).

"Advances in Simulating Tokamak Turbulent Transport", G.W. Hammett, M.A. Beer, J.C. Cummings, W. Dorland, et al., 15th Int. Conf. on Plasma Physics and Controlled Nuclear Fusion Research, (Seville, Spain, 1994), Vol. III, p. 273 (IAEA, 1995).

"Developments in the Gyrofluid Approach to Tokamak Turbulence Simulations" G.W. Hammett, M.A. Beer, W. Dorland, S.C. Cowley, and S.A. Smith, Invited Talk, 1993 Sherwood Int. Fusion Theory Conf., Plasma Phys. Control. Fusion 35, 973 (1993).

"Fluid models of phase mixing, Landau damping, and nonlinear gyrokinetic dynamics", G.W. Hammett, W. Dorland, and F.W. Perkins, Invited Talk, 1991 Meeting of the American Physical Society, Division of Plasma Physics, Phys. Fluids B 4, 2052 (1992).

"Studies of Energetic Ions Produced During ICRF Heating in PLT", G.W. Hammett, Invited Talk, American Physical Society, Division of Plasma Physics 1986 meeting.