

UCSD FINAL REPORT

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Gyrokinetic Simulation of Energetic Particle Turbulence and Transport

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Executive Summary

Progress in research during this year elucidated the physics of precession resonance and its interaction with radial scattering to form phase space density granulations. Momentum theorems for drift wave-zonal flow systems involving precession resonance were derived. These are directly generalizable to energetic particle modes. A novel nonlinear, subcritical growth mechanism was identified, which has now been verified by simulation. These results strengthen the foundation of our understanding of transport in burning plasmas.

Technical Report

During this time period the UCSD group and its collaborators produced over 88 papers, all of which are relevant to GSEP, in general terms.

Of particular note for GSEP is the recent progress in phase space density granulation and subcritical instability in drift wave systems with magnetic precession resonance. These are contained in Diamond, et al. (Aix '09 volume), Kosuga and Diamond (submitted to PoP) and Lesur, et al. (submitted). These works outline a theory of subcritical nonlinear instability of phase space structures in the seminal Berk and Briezman model. They also derive a fundamental momentum conservation theorem for turbulence and zonal flows in a system with precession resonance. The theory of phase space structure growth in kinetic drift wave turbulence is also developed. The relation to intrinsic rotation has been noted.

The results discussed here are directly generalizable to the case of energetic particle mode turbulence. That work is ongoing.

UCSD Group Members

- Patrick H. Diamond (Principal Investigator)
- Fred L. Hinton (Senior Research Scientist)
- Mikhail Malkov (Research Scientist)
- Ozgur Gurcan (Postdoctoral Researcher)
- Christopher McDevitt (Postdoctoral Researcher)
- Kazuhiro Miki (Postdoctoral Researcher)
- Guilhem Dif-Pradalier (Postdoctoral Researcher)
- Shane Keating (Graduate Student Researcher)
- Yusuke Kosuga (Graduate Student Researcher)
- Lei Zhao (Graduate Student Researcher)
- Christopher Lee (Graduate Student Researcher)
- Pei-Chun Hsu (Graduate Student Researcher)
- Zhanhui Wang (Visiting Graduate Student Researcher)
- Zhibin Guo (Short Term Visiting Graduate Student Researcher)
- Andrew Ulvestad (Undergraduate Research Assistant)

UCSD Group External Recognition

- *European Physical Society-2011 Hannes Alfvén Prize*
Awarded to Patrick H. Diamond, shared with Akira Hasegawa and Kunioki Mima, Osaka University, for outstanding contributions to plasma physics. The three were recognized "for laying the foundations of modern numerical transport simulations and key contributions on self-generated zonal flows and flow shear decorrelation mechanisms which form the basis of modern turbulence in plasmas".
- *Director, WCI Center for Fusion Theory, NFRI, Daejeon, Korea, 2011*
Patrick H. Diamond
- *2009 EPS Plasma Physics Division 2009 Ph.D. Research Award*
Awarded to Guilhem Dif-Pradalier
- *2010 National Science Foundation Graduate Research Fellowship*
Awarded to Andrew Ulvestad
- *2010 Selma and Robert Silagi Award for Undergraduate Excellence*
Awarded to Andrew Ulvestad

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89. Diamond, P.H., Y. Kosuga and M. Lesur, "Dynamics of Structures in Configuration Space and Phase Space: An Introductory Tutorial", *Festival de Theorie 2009 Volume - To Be Published* (35 pp.)
90. Malkov, M.A., R.Z. Sagdeev and P.H. Diamond, "UHECR Acceleration Around Filaments of Cosmological Structure Formation", *Proceedings of the 32nd*

- International Cosmic Ray Conference, Beijing, China, 2011, Accepted for Publication
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 92. Sagdeev, R.Z., M.A. Malkov, P.H. Diamond and L.O.C. Drury, "Probing Nearby CR Accelerators with Milagro/IceCube Hot Spots", Proceedings of the 32nd International Cosmic Ray Conference, Beijing, China, 2011, Accepted for Publication
 93. Diamond, P.H., M.A. Malkov and R.Z. Sagdeev, "Cosmic Ray Fronts Ahead of SNR Shocks", Proceedings of the 32nd International Cosmic Ray Conference, Beijing, China, 2011, Accepted for Publication
 94. Sun, H.J., P.H. Diamond, Z.B. Shi, C.Y. Chen, L.H. Yao, X.T. Ding, B.B. Feng, X.L. Huang, J. Zhou, X.M. Song, the HL-2A, "Experimental Evidence of the Non-Local Response of Transport to Peripheral Perturbations", Nucl. Fusion, Accepted for Publication
 95. Diamond, P.H., A. Hasegawa, K. Mima, "Vorticity Dynamics, Drift Wave Turbulence, and Zonal Flows: A Look Back and a Look Ahead", Plas. Phys. Control. Fusion, Accepted for Publication
 96. Malkov, M.A., P.H. Diamond, L.O.C. Drury and R.Z. Sagdeev, "Angular Distribution of Energetic Particles Scattered by Strongly Anisotropic MHD Turbulence: Understanding Milagro/IceCube Results", 10th Annual International Astrophysics Conference, 13-18 March 2011, Maui, Hawaii, AIP Conference Proceedings, ed. G.P. Zank, Submitted for Publication
 97. Hinton, F.L., "Effect of Superbanana Diffusion on the Fusion Reactivity in QHS Stellarators", Phys. Plasma, Submitted for Publication
 98. Kosuga, Y. and P.H. Diamond, "On Relaxation and Transport in Gyrokinetic Drift Wave Turbulence with Zonal Flow, Phys. Plasma, Submitted for Publication

UCSD Group Web Site

A web site, <http://cass.ucsd.edu/groups/plasma/gps-ttbp/index.html>, for the Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas (GPS-TTBP) project was created listing the goals of the research sponsored center, the people involved, publications related to the research and news and meetings information.

UCSD Presentations

1. *Physics and Modeling of Multi-Scale Interaction in Plasmas*, Invited Speaker, Kyoto University, Kyoto, Japan, 03/03-04/08 (Diamond - Unable to attend due to schedule conflicts)
2. *Geophysical Wave Interactions in Turbulent Magnetofluids*, Oral Presentation, Joint CAOS-MFD Seminar, Courant Institute, New York University, New York, NY, 03/08 (Keating)

3. *Mechanisms of Edge-Core Coupling: Some Speculations on How SOL Flows Influence Intrinsic Rotation and the L-H Transition*, Oral Presentation, 2008 U.S. Transport Task Force Meeting, Boulder, CO, 03/08 (Diamond)
4. *Poloidal Reynolds Stress, and its Influence on Intrinsic Rotation/Momentum Transport*, Oral Presentation, 2008 U.S. Transport Task Force Meeting, Boulder, CO, 03/08 (Gurcan)
5. *Transport of Parallel Momentum by Collisionless Electromagnetic Turbulence*, Oral Presentation, 2008 U.S. Transport Task Force Meeting, Boulder, CO, 03/08 (McDevitt)
6. *Non-Random Collision Method for Delta-f PIC Simulations*, Poster Presentation, 2008 U.S. Transport Task Force Meeting, Boulder, CO, 03/08 (Hinton)
7. *Formation and Propagation of Transport Barriers in a Coupled Heat and Particle Flux Model*, Poster Presentation, 2008 U.S. Transport Task Force Meeting, Boulder, CO, 03/08 (Malkov)
8. *Theoretical Approaches to Problem Reduction and Description of Multi-Scale Interaction in Tokamak Plasma Turbulence*, Oral Presentation, International Workshop on 'Multiscale Methods for Fluid and Plasma Turbulence: Applications to Magnetically Confined Plasmas in Fusion Devices', CIRM, Marseille, France, 04/08 (Diamond)
9. *'Thoughts on 'Thetergy', Is Magnetostrophic Turbulence As Simple As It Looks?'*, Oral Presentation, Dynamo Theory Program, KITP Institute for Theoretical Physics, University of California at Santa Barbara, Santa Barbara, CA, 05/08 (Diamond)
10. *Mean Field MHD of (Magnetized Circumstellar) Accretion Disks*, Oral Presentation, Dynamo Theory Program, KITP Institute for Theoretical Physics, University of California at Santa Barbara, Santa Barbara, CA, 05/08 (Diamond)
11. *Quenching and Irreversibility in 2D Wavy MHD*, Oral Presentation, Dynamo Theory Program, KITP Institute for Theoretical Physics, University of California at Santa Barbara, Santa Barbara, CA, 05/08 (Keating)
12. *Momentum Theorems and the Structure of Atmospheric Jets and Zonal Flows in Plasmas*, Invited Speaker, The 35th European Physical Society Conference on Plasma Physics, Hersonissos, Crete, Greece, 06/08 (Diamond)
13. *Zonal Flow Generation Mechanisms - Wave Number and Configuration Space Perspectives*, Oral Presentation, Dynamo Theory Program, KITP Institute for Theoretical Physics, University of California at Santa Barbara, Santa Barbara, CA, 06/08 (Diamond)
14. *On the Fate of PV Homogenization with Magnetic Linkage and its Implication for Jet Formation in MHD*, Oral Presentation, Magnetic Field Generation in Experiments, Geophysics and Astrophysics Conference, Dynamo Theory Program, KITP Institute for Theoretical Physics, University of California at Santa Barbara, Santa Barbara, CA, 07/08 (Diamond)
15. *Mechanisms of Edge-Core Coupling: How SOL Flow Might Influence Intrinsic Rotation and the L-H Transition*, Invited Talk, European-U.S. Transport Task Force 2008 Workshop, Copenhagen, Denmark, 09/08 (Diamond - Unable to attend, T.S. Hahm presented talk)

16. *Toroidal Momentum Transport and Intrinsic Rotation: A Critical Transport Physics Issue for ITER and Beyond...*, Invited Speaker, 14th International Congress on Plasma Physics, Fukuoka, Japan, 09/08 (Diamond)
17. *Toroidal Momentum Transport and Intrinsic Rotation: A Critical Transport Physics Issue for ITER and Beyond...*, Invited Speaker, JAEA Seminar, Naka, Japan, 09/08 (Diamond)
18. *An Emerging Understanding of Momentum Transport and Intrinsic Rotation in Tokamaks*, Invited Speaker, Special Plasma Physics Seminar, University of California at Irvine, Irvine, CA, 10/08 (Diamond)
19. *Physics of Non-Diffusive Turbulent Transport of Momentum and the Origins of Spontaneous Rotation in Tokamaks*, Oral Presentation, 22nd IAEA Fusion Energy Conference, Geneva, Switzerland, 10/08 (Diamond - Unable to attend-talk presented by T.S. Hahm, PPPL)
20. *Interaction of Energetic Particles with Discontinuities Upstream*, Invited Talk, APS 50th Annual Meeting of the Division of Plasma Physics, Mini-Conference, Dallas, TX, 11/08 (Malkov)
21. *Impact of Collisions on Turbulence and Transport*, Oral Presentation, APS 50th Annual Meeting of the Division of Plasma Physics, Dallas, TX, 11/08 (Dif-Pradalier)
22. *Analysis of Feedback Loop Dynamics in Turbulence Spreading*, Poster Presentation, APS 50th Annual Meeting of the Division of Plasma Physics, Dallas, TX, 11/08 (Miki)
23. *Gyrokinetic Simulations Predict Anomalous Poloidal Rotation in Tokamak Plasmas*, Oral Presentation, APS 50th Annual Meeting of the Division of Plasma Physics, Dallas, TX, 11/08 (Dif-Pradalier)
24. *On the Fate of PV Homogenization with Magnetic Linkage and its Implication for Jet Formation in MHD*, Poster Presentation, APS 50th Annual Meeting of the Division of Plasma Physics, Dallas, TX, 11/08 (Keating)
25. *Improved δ - f Method*, Oral Presentation, CPES Meeting, Atlanta, GA, 12/08 (Hinton)
26. *Physics of Non-Diffusive Turbulent Transport of Momentum and Origins of Spontaneous Rotation in Tokamaks*, Oral Presentation, Fusion SciDAC Winter School on Turbulence and Energetic Particles, Irvine, CA, 02/09 (Diamond)
27. *Toroidal Momentum Transport and Intrinsic Rotation*, Oral Presentation, Fusion SciDAC Winter School on Turbulence and Energetic Particles, Irvine, CA, 02/09 (Diamond)
28. *Fermi Acceleration, Cosmic Rays and Fermi Mission*, Oral Presentation, Fermi Seminar, Berkeley, CA, 02/09 (Malkov)
29. *On Hysteresis of the H-L Back-Transition*, Oral Presentation, 2009 Joint US-EU Transport Task Force, San Diego, CA, 04-05/2009 (Malkov)
30. *Effect of Pedestal and SOL Physics on Core Rotation*, Oral Presentation, 2009 Joint US-EU Transport Task Force, San Diego, CA, 04-05/2009 (McDevitt)
31. *Analysis of GAM Shear Feedback Loop Dynamics in Transport Bifurcations and Turbulence Spreading*, Oral Presentation, 2009 Joint US-EU Transport Task Force Workshop, San Diego, CA, 04-05/2009 (Miki)

32. *A Second Look at Zonal Flow Dynamics*, Oral Presentation, 2009 Joint EU-US Transport Task Force Workshop, San Diego, CA, 04-05/2009 (Diamond)
33. *Re-visiting Poloidal Rotation and Transport Near Criticality*, Oral Presentation, 2009 Joint EU-US Transport Task Force, San Diego, CA, 04-05/2009 (Dif-Pradalier)
34. *Dynamics of Flux-Driven Turbulence Spreading with Self-Consistent Nonlinear Noise*, Poster Presentation, Joint U.S.-EU 2009 Transport Task Force Workshop, San Diego, CA, 04/09 (Wang)
35. *Self-Consistent Calculations of Zonal Flow Shears and Stability*, Poster Presentation, Joint U.S.-EU 2009 Transport Task Force Workshop, San Diego, CA, 04/09 (Kosuga)
36. *Momentum Transport*, Oral Presentation, CPES 2009 Spring Meeting, San Diego, 05/09 (Diamond)
37. *Direct Implicit Method for Drift-Kinetic Electrons in Collisionless PIC Simulations*, Oral Presentation, CPES 2009 Spring Meeting, San Diego, CA, 05/09 (Hinton)
38. 8th Annual International Astrophysics Conference, Invited Speaker, Kailua-Kona, HI, 05/01-05/07/09 (Diamond - Unable to attend due to schedule conflicts, M.A. Malkov presented talk)
39. *Wave Dynamics and Particle Acceleration in Shock Precursors*, Invited Speaker, 8th Annual International Astrophysics Conference, Kailua-Kona, HI, 05/09 (Malkov)
40. *Fluid and Gyrokinetic Momentum Theorems for Drift Wave - Zonal Flow Turbulence*, Invited Speaker, The 4th IAEA Technical Meeting on the Theory of Plasma Instabilities, Kyoto, Japan, 5/09 (Diamond - Unable to attend due to the influenza A (H1N1) outbreak in Japan)
41. *Self-Consistent Calculation of Turbulent Momentum Transport and Intrinsic Rotation: Viscosity, Pinch and Residual Stress*, Oral Presentation, The 4th IAEA Technical Meeting on the Theory of Plasma Instabilities, Kyoto, Japan, 05/09 (McDevitt)
42. *Analysis of GAM Shear Feedback Loop Dynamics in Transport Bifurcations and Turbulence Spreading*, Poster Presentation, The 4th IAEA Technical Meeting on the Theory of Plasma Instabilities, Kyoto, Japan, 05/09 (Miki)
43. Hasegawa-Mima Equation: 30 Year and Future, Invited Speaker, Kyoto University, Kyoto, Japan, 05/09 (Diamond - Unable to attend)
44. *Chaotic Dynamics and the Acceleration of High Energy Cosmic Rays by Nonlinear Shocks*, Invited Speaker, Minisymposium Conference on Applications of Dynamical Systems, Society for Industrial and Applied Mathematics (SIAM), Snowbird, UT, 05/09 (Diamond - Unable to attend due to schedule conflict)
45. *Dynamics of Granulations in GFD and Vlasov Plasmas*, Lecturer, 4th Festival de Theorie, Aix-en-Provence, France, 07/09 (Diamond)
46. *Turbulence, Profile Dynamics and Collisions: Investigating Their Interplay*, Short Talk, 4th Festival de Theorie, Aix-en-Provence, France, 07/09 (Dif-Pradalier)
47. *Wave Phenomena and Cosmic Ray Acceleration Ahead of Strong Shocks*, Oral Presentation, TeV Particle Astrophysics, SLAC National Accelerator Laboratory, Menlo Park, CA, 07/09 (Malkov)

48. *Introduction to Quasilinear Theory*, Invited Speaker, Korean Fusion Plasma Summer School 2009, Korea Advanced Institute of Science and Technology, Daejeon, Korea, 07/09 (Diamond)
49. International Conference "Turbulent Mixing and Beyond", Invited Key-Note Lecturer, Trieste, Italy, 07-08/09 (Diamond - Unable to attend due to conference schedule conflict)
50. *Acoustic Turbulence and Particle Acceleration in CR-Modified Shocks*, Oral Presentation, Particle Acceleration in Astrophysical Plasmas, KITP, Santa Barbara, CA, 09/09 (Malkov)
51. *Stabilization of the CR-Driven Non-Resonant Instabilities*, Invited Speaker, Nonlinear Processes in Astrophysical Plasmas: Particle Acceleration, Magnetic Field, Amplification and Radiation Signatures, Santa Barbara, CA, 09-10/09 (Malkov)
52. *Radial Current, Residual Stress and Intrinsic Rotation*, Poster Presentation, 12th International Workshop on H-mode Physics and Transport Barriers, Princeton Plasma Physics Laboratory, Princeton, NJ, 09-10/09 (Diamond)
53. *Rotation Dynamics With & Without Internal Transport Barriers*, Oral/Poster Presentation, 12th International Workshop on H-mode Physics and Transport Barriers, Princeton Plasma Physics Laboratory, Princeton, NJ, 09-10/09 (Dif-Pradalier)
54. *A Simple Dynamical Model of Flux-Driven Turbulence and Profile Evolution*, Oral/Poster Presentation, 12th International Workshop on H-mode Physics and Transport Barriers, Princeton Plasma Physics Laboratory, Princeton, NJ, 09-10/09 (Wang)
55. *A Simple Non-Perturbative Model of Turbulence Spreading in the Presence of Dissipation and Zonal Flows*, Poster Presentation, 12th International Workshop on H-mode Physics and Transport Barriers, Princeton Plasma Physics Laboratory, Princeton, NJ, 09-10/09 (Diamond)
56. *GAM Shearing Feedback Loop in Transport Bifurcation and Turbulence Spreading*, Poster Presentation, 12th International Workshop on H-mode Physics and Transport Barriers, Princeton Plasma Physics Laboratory, Princeton, NJ, 09-10/09 (Miki)
57. *Toroidal and Poloidal Flow Evolution*, Poster Presentation, 12th International Workshop on H-mode Physics and Transport Barriers, Princeton Plasma Physics Laboratory, Princeton, NJ, 09-10/09 (McDevitt)
58. *Potential Vorticity Dynamics in Drift Wave & MHD Turbulence*, Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas, University of Wisconsin-Madison, Madison, WI, 10/09 (Diamond - Unable to attend due to illness)
59. *A Second Look at Zonal Flows*, Invited Talk, APS 51st Annual Meeting of the Division of Plasma Physics, Atlanta, GA 11/09 (Diamond)
60. *GAM Shear Feedback Loop Dynamics in Transport Bifurcations and Turbulence Spreading*, Oral Presentation, 51st Annual Meeting of the Division of Plasma Physics, Atlanta, GA, 11/09 (Miki)

61. *On the Validity of the Local Diffusive Paradigm in Turbulent Plasma Transport*, Poster and Oral Presentations, APS 51st Annual Meeting of the Division of Plasma Physics, Atlanta, GA, 11/09 (Dif-Pradalier)
62. *On Modeling Multi-Scale Interaction in DSA*, Invited Talk, 5th Korean Astrophysics Workshop Shock Waves, Turbulence, and Particle Acceleration, APCTP, Pohang, Korea, 11/09 (Diamond)
63. *Analytic Studies of the Diffusive Shock Acceleration*, Invited Talk, 5th Korean Astrophysics Workshop Shock Waves, Turbulence, and Particle Acceleration, APCTP, Pohang, Korea, 11/09 (Malkov)
64. Japan Society of Plasma and Fusion, Invited Speaker, Kyoto, Japan, 12/09 (Diamond - Unable to attend due to schedule conflict)
65. *Wave Momentum, Potential Vorticity Mixing, Symmetry Breaking and the Physics Self-Accelerating Plasma Flows*, Invited Plenary Speaker, The 19th International Toki Conference on Advanced Physics in Plasma and Fusion Research, Toki-City, Gifu, Japan, 12/09 (Diamond)
66. *Issues in the Theory of Intrinsic Rotation*, Oral Presentation, Center for Momentum Transport and Flow Self-Organization in Plasmas Workshop, La Jolla, CA, 1/10 (Diamond)
67. *Dynamics of Pedestal Formation*, Oral Presentation, DIII-D Pedestal Transport Workshop, San Diego, CA, 02/10 (Diamond)
68. *Spreading and Overshoot in Drift Wave Turbulence*, Oral Presentation, Nonlinear Wave Workshop 8, La Jolla, CA, 03/10 (Diamond)
69. *Instabilities in Astrophysical Shock Precursors and Their Saturation*, Oral Presentation, Nonlinear Wave Workshop 8, La Jolla, CA, 03/10 (Malkov)
70. *Momentum Theorems for Zonal and Toroidal Flows in Drift Wave Turbulence*, Oral Presentation, JIFT Workshop, La Jolla, CA, 03/10 (Diamond)
71. *Spreading and Entrainment in 2D and Drift Wave Turbulence*, Oral Presentation, JIFT Workshop, La Jolla, CA, 03/10 (Ulvestad, Diamond)
72. *Turbulent Transport and Acceleration of Cosmic Rays in Supernova Remnant Shocks*, Oral Presentation, JIFT Workshop, La Jolla, CA, 03/10 (Malkov)
73. *Non-Locality in Transport*, Oral Presentation, JIFT Workshop, La Jolla, CA, 03/10 (Dif-Pradalier)
74. *An Edge Turbulence Model with Multi-Frequency Shearing Effects*, Oral Presentation, JIFT Workshop, La Jolla, CA, 03/10 (Miki)
75. *Enstrophy, Entropy and Efficiency in Flow Generation*, Oral Presentation, JIFT Workshop, La Jolla, CA, 03/10 (Kosuga)
76. *Turbulent Transport of Poloidal and Toroidal Momentum*, Oral Presentation, 4th ITPA Transport & Confinement Meeting, Culham, Oxford, UK, 03/10 (McDevitt)
77. *Progress in the Theory of Pedestal Evolution*, Oral Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD, 04/10 (Diamond)
78. *Poloidal Rotation and Its Relation to the Mixing of Potential Vorticity*, Oral Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD, 04/10 (McDevitt)
79. *On the Validity of the Local Diffusive Paradigm in Turbulent Plasma Transport*, Oral Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD, 04/10 (Dif-Pradalier)

80. *Quantifying the Efficiency of the Spontaneous Flow Generation "Engine" in Confined Plasmas*, Oral Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD, 04/10 (Kosuga)
81. *Methods for Simulating Collisions in Particle Codes*, Poster Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD, 04/10 (Hinton)
82. *An Edge Turbulence Model with Multi-Frequency Shearing Effects*, Oral Presentation, 2010 U.S. Transport Task Force Meeting, Annapolis, MD, 04/10 (Miki)
83. *Current Driven Drift-ITG Turbulence*, Poster Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD 04/10 (Lee)
84. *Inter-species Energy Transfer and Turbulent Heating in Drift Wave Turbulence*, Poster Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD 04/10 (Zhao)
85. *Penetrative Overshoot and the Spatial Distribution of Drift Wave Turbulence*, Poster Presentation, 2010 U.S. Transport Task Force Workshop, Annapolis, MD 04/10 (Ulvestad)
86. *Problems and Opportunities in L-H Transition and Intrinsic Rotation Physics*, Oral Presentation, Fifth US-PRC Magnetic Fusion Collaboration Workshop, Huazhong University of Science and Technology (HUST), Wuhan, China, 05/10 (Diamond)
87. *Analytic Studies of Astrophysical Shock Precursors*, Invited Speaker, 37th European Physical Society Conference on Plasma Physics, Dublin, Rep. of Ireland, 06/10 (Malkov)
88. *From the Interplay Between Flows, Collisions and Turbulence to the Question of the Non-Local, Non-Diffusive Character of Tokamak Transport*, Oral Presentation, 37th European Physical Society Conference on Plasma Physics, Dublin, Rep. of Ireland, 06/10 (Dif-Pradalier)
89. *Instabilities and CR Confinement in Shocks: Impact on CR Spectra and Shock Morphology*, Invited Talk, Dublin Institute for Advanced Study, Dublin, Rep. of Ireland, 06/10 (Malkov)
90. *On the Validity of the Local Diffusive Paradigm in Turbulent Plasma Transport*, Oral Presentation, Workshop on Electric Fields, Turbulence and Self-Organization in Magnetized Plasmas-a satellite meeting of the 37th European Physical Society Conference on Plasma Physics, Dublin, Rep. of Ireland, 06/10 (Dif-Pradalier)
91. *From Kinetic Theory to Microscopic Transport*, Oral Presentation, ISIMA Conference: Transport Processes in Astrophysics, Santa Cruz, CA, 07/10 (Diamond)
92. *The Edge Temperature Gradient as the Intrinsic Rotation Drive in Alcator C-Mod Tokamak Plasmas*, Oral Presentation, 3rd EFDA Transport Topical Group Meeting combined with the 15th EU-US Transport Task Force Meeting, Cordoba, Spain, 09/10 (Diamond)
93. *Poloidal Rotation in Strongly Magnetized Plasmas*, Oral Presentation, 3rd EFDA Transport Topical Group Meeting combined with the 15th EU-US Transport Task Force Meeting, Cordoba, Spain, 09/10 (McDevitt)

94. *Role of Neoclassical and Turbulence Mechanisms on Rotation and Flow Structure Formation*, Oral Presentation, 3rd EFDA Transport Topical Group Meeting combined with the 15th EU-US Transport Task Force Meeting, Cordoba, Spain, 09/10 (Dif-Pradalier)
95. *Nonlocal Dynamics of Turbulence, Transport and Zonal Flows in Tokamak Plasmas*, Poster Presentation, 23rd IAEA Fusion Energy Conference, Daejeon, Rep. of S. Korea, 10/10 (Dif-Pradalier)
96. *Developments in the Theory of Tokamks Flow Self-Organization*, Poster Presentation, 23rd IAEA Fusion Energy Conference, Daejeon, Rep. of S. Korea, 10/10 (McDevitt)
97. *Boundary Layer and Streamer Flows in Interchange-Unstable Plasma*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Malkov)
98. *Interaction of Charged Particles with Collisionless Shock Ensembles*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Malkov)
99. *Poloidal Rotation in Strongly Magnetized Plasmas*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (McDevitt)
100. *Momentum Studies with Sources and Sinks in Fusion*, Oral Presentation, Mini-Conference on Momentum Transport in Magnetic Fusion and Astrophysical Systems I, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Dif-Pradalier)
101. *On Flow Structures and the Hierarchy of Shears*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Dif-Pradalier)
102. *On the Efficiency of Intrinsic Rotation Generation in Tokamaks*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Kosuga)
103. *Inter-species Energy Transfer and Turbulent Heating in CTEM*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Zhao)
104. *Current Driven Drift Wave Turbulence*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Lee)
105. *Hyper-resistivity in 2D-MHD Turbulence*, Poster Presentation, 52nd Annual Meeting of the APS Division of Plasma Physics, Chicago, IL, 11/10 (Guo)
106. *Multi-Scale Interaction in Diffusive Shock Acceleration*, Invited Colloquium Speaker, Joint Plasma Kavli Institute for Astronomy and Astrophysics, Peking University, People's Republic of China, 01/11 (Diamond)
107. *Intrinsic Rotation and Toroidal Momentum Transport: Status and Prospects*, Oral Presentation, Center for Momentum Transport and Flow Organization Annual Meeting, New Orleans, LA, 01/11 (Diamond)
108. *Zonal Flow Physics-A Momentum Transport Perspective*, Oral Presentation, Center for Momentum Transport and Flow Organization Annual Meeting, New Orleans, LA, 01/11 (Diamond)

109. *Some Ideas on Flow Structure, Nonlocality & Staircases*, Oral Presentation, Center for Momentum Transport and Flow Organization Annual Meeting, New Orleans, LA, 01/11 (Dif-Pradalier)
110. *Transport in Stochastic Fields and MHD Turbulence*, Oral Presentation, WCI-CNU Astro-Fusion Plasma Joint Meeting, Daejeon, Korea, 02/11 (Diamond)
111. *Intrinsic Rotation and Toroidal Momentum Transport: Status and Prospects (A Largely Theoretical Perspective)*, Invited Talk, 2011 KSTAR Conference and KO-US Workshop, Muju, Korea, 02/11 (Diamond)
112. *Drift Waves Turbulence and Flows*, Oral Presentation, Dynamics and Turbulent Transport in Plasmas and Conducting Fluids, Ecole de Physique des Houches, France, 02-03/11 (Diamond)
113. *Zonal Flows: From Wave Momentum and Potential Vorticity Mixing to Shearing Feedback Loops and Enhanced Confinement*, Oral Presentation, Dynamics and Turbulent Transport in Plasmas and Conducting Fluids, Ecole de Physique des Houches, France, 02-03/11 (Diamond)
114. *A Theory of the Efficiency of the Plasma Flow Generation*, Oral Presentation, Dynamics and Turbulent Transport in Plasmas and Conducting Fluids, Ecole de Physique des Houches, France, 02-03/11 (Kosuga)
115. *Intrinsic Rotation and Toroidal Momentum Transport: Status and Prospects*, Oral Presentation, Dynamics and Turbulent Transport in Plasmas and Conducting Fluids, Ecole de Physique des Houches, France, 02-03/11 (Diamond)

Visitors to UCSD for the Purpose of Research and Collaboration

1. T.S. Hahm (PPPL), Y. Xiao (UCI), W. Zhang (UCI), L. Chen (UCI), I. Holod (UCI), G. Rewoldt (PPPL), W. Horton (UT Austin), Z. Lin (UCI), A. White (UCLA), S. Kaye (PPPL) - GPS-TTBP Research and Collaboration Meeting, UC San Diego, La Jolla, CA, 02-03/08
2. Yansong Wang (PPPL) 04/08
3. Guilhem Dif-Pradalier (CEA Cadarache, France) 04/08
4. Taik-Soo Hahm (Princeton Plasma Physics Laboratory) 06/08
5. Junjun Liu (California Institute of Technology) 10/08
6. Michael Van Zeeland (General Atomics) 10/08
7. Andrey Beresnyak (University of Wisconsin) 10/08
8. Naohiro Kasuya (National Institute for Fusion Science) 11/08
9. Stanley Kaye (Princeton Plasma Physics Laboratory) 02/09
10. Nic Brummell (University of California, Santa Cruz) 02/09
11. Tamara Rogers (University of Arizona) 03/09
12. Yong Xiao (University of California, Irvine) 03/09
13. Edriss Titi (University of California, Irvine) 04/09
14. Mark Miesch (University of Colorado, Boulder), 04/09
15. C.S. Chang (CIMS, New York University) 05/09
16. Xavier Garbet (CEA) 05/09
17. Ozgur Gurcan (CEA) 05/09
18. Carlos Hidalgo (CIEMAT) 05/09
19. Kenichi Nagaoka (NIFS) 05/09

20. Katsumi Ida (*NIFS*) 05/09
21. Takeshi Ido (*NIFS*) 05/09
22. Naohiro Kasuya (*NIFS*) 05/09
23. Mark Miesch (*University of Colorado, Boulder*) 05/09
24. Annick Pouquet (*NCAR*) 05/09
25. Luke Drury (*Dublin Institute for Advanced Studies*) 09/09
26. Lu Wang (*PPPL*) 11/09
27. Taik-Soo Hahm (*PPPL*) 01/10
28. Janghoon Seo (*KAIST, Daejeon, ROK*) 02/10-03/10
29. Wayne Solomon (*PPPL/General Atomics*) 03/10
30. Eric King (*UCLA*) 3/10
31. Roald Sagdeev (*University of Maryland, College Park*) 05/10
32. Wolf Mueller (*Max Planck Institute for Plasma Physics*) 06/10

UCSD Group Travel/Research and Collaboration

1. *Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas and Gyrokinetic Simulation of Energetic Particle Turbulent and Transport Workshop Meetings and Research and Collaboration*, UC Irvine, Irvine, CA (Diamond, Gurcan) 01/08
2. *Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas Research and Collaboration Meeting*, UC San Diego, La Jolla, CA (Diamond, Malkov, Hinton, Gurcan, McDevitt, Keating, Wang) 02-03/08
3. *21st U.S. Transport Task Force Workshop Meeting*, Boulder, CO (Diamond, Malkov, Hinton, Gurcan, McDevitt, Wang) 03/08
4. *Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas Meeting and Research and Collaboration*, Boulder, CO (Diamond, Malkov, Hinton, Gurcan, McDevitt, Wang) 03/08
5. *Dynamo Theory Workshop*, Kavli Institute for Theoretical Physics, UC Santa Barbara, Santa Barbara, CA (Diamond, Keating) 05-07/08
6. *Magnetic Field Generation in Experiments, Geophysics and Astrophysics Conference*, Kavli Institute for Theoretical Physics, UC Santa Barbara, Santa Barbara, CA (Diamond, Keating) 07/08
7. *Research and Collaboration*, UC Irvine, Irvine, CA (Miki) 10/08
8. *Research and Collaboration*, UC Irvine, Irvine, CA (Diamond, Miki) 10/08
9. *22nd IAEA Fusion Energy Conference and Research and Collaboration*, Geneva, Switzerland (McDevitt) 10/08
10. *50th Annual Meeting of the APS/DPP, Research and Collaboration*, Dallas, TX (Diamond, Malkov, Hinton, McDevitt, Wang, Miki, Dif-Pradalier) 11/08
11. *Gyrokinetic Particle Simulation of Turbulent Transport in Burning Plasmas and Gyrokinetic Simulation of Energetic Particle Turbulent and Transport Workshop Meeting and Research and Collaboration*, Dallas, TX (Diamond, Malkov, Hinton, Miki, Dif-Pradalier, Wang) 11/08
12. *CPES Fall Meeting and Research and Collaboration*, Atlanta, GA (Hinton, Dif-Pradalier) 12/08

13. *Lectures and Research and Collaboration*, Peking University, Beijing, China (Diamond) 12/08
14. *XGCI Meeting and Research and Collaboration*, Courant Institute of Mathematical Sciences at NYU, New York, NY (Diamond, Dif-Pradalier) 01/09
15. *Fermi Workshop and Research and Collaboration*, UC Berkeley, Berkeley, CA (Malkov) 02/09
16. *Fusion SciDAC Winter School on Turbulence and Energetic Particles and Research and Collaboration*, UC Irvine, Irvine, CA (Diamond, McDevitt, Miki, Dif-Pradalier, Hsu, Kosuga, Wang, Lee, Hsu) 02/09
17. *MIT Plasma Science and Fusion Center Seminar Speaker and Research and Collaboration*, MIT, Cambridge, MA (Diamond) 03/09
18. *Research and Collaboration*, PPPL, Princeton, NJ (Diamond) 03/09
19. *Research and Collaboration*, Washington DC (Diamond) 04/09
20. *U.S.- EU 2009 Transport Task Force Workshop Meeting and Research and Collaboration*, San Diego, CA (Diamond, Malkov, Hinton, McDevitt, Miki, Dif-Pradalier, Wang, Kosuga, Zhao, Lee, Hsu) 04/09
21. *SciDAC Prototype FSP Center for Plasma Edge Simulation Meeting and Research and Collaboration*, UC San Diego, La Jolla, CA (Diamond, Dif-Pradalier) 04/09
22. *CPES Meeting*, San Diego, CA (Hinton) 05/09
23. *8th Annual International Astrophysics Conference and Research and Collaboration*, Kona, Hawaii (Malkov) 05/09
24. *The 4th IAEA Technical Meeting on the Theory of Plasma Instabilities*, Kyoto University, Kyoto, Japan (McDevitt, Miki) 05/09
25. *Lecture Meeting of the Hasegawa-Mima Equation and Research and Collaboration*, Kyoto University, Kyoto, Japan (Miki) 05/09
26. *Lectures and Research and Collaboration*, Korea Advanced Institute of Science and Technology, Daejeon, Republic of South Korea (Diamond) 06/09
27. *Rotation and Momentum Transport in Magnetized Plasmas at the Festival de Theorie 2009*, Aix-en-Provence, France (Diamond, McDevitt, Miki, Dif-Pradalier) 07/09
28. *TeV Particle Astrophysics 2009*, SLAC National Accelerator Laboratory, Menlo Park, CA (Malkov) 07/09
29. *Lectures and Research and Collaboration*, Korea Advanced Institute of Science and Technology, Daejeon, Republic of South Korea (Diamond, Dif-Pradalier) 07-08/09
30. *Lectures and Research and Collaboration*, Peking University, Beijing, China (Diamond) 08/09
31. *Nonlinear Processes in Astrophysical Plasmas: Particle Acceleration, Magnetic Field Amplification and Radiation Signatures*, Kavli Institute for Theoretical Physics, UC Santa Barbara, Santa Barbara, CA (Malkov) 08/09/10-09
32. *Research and Collaboration*, Oak Ridge National Laboratory, Oak Ridge, TN (Dif-Pradalier) 09/09
33. *12th International Workshop on 'H-Mode Physics and Transport Barriers'*, Princeton University, Plasma Physics Laboratory, (Diamond, McDevitt, Hinton, Miki, Dif-Pradalier, Wang, Kosuga, Lee) 09-10/09

34. *ITPA Joint Transport & Confinement/Pedestal Meetings and Research and Collaboration*, PPPL, Princeton, NJ (Diamond, McDevitt) 10/09
35. *Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas General Meeting*, University of Wisconsin, Madison, WI (Diamond - Unable to attend due to illness) 10/09
36. *51st Annual Meeting of the APS/DPP, Research and Collaboration*, Atlanta, GA (Diamond, Hinton, McDevitt, Miki, Dif-Pradalier, Kosuga, Lee; Malkov - Unable to attend due to schedule conflict) 11/09
37. *Fermi Meeting*, Washington, DC (Malkov) 11/09
38. *5th Korean Astrophysics Workshop-Shock Waves, Turbulence and Particle Acceleration*, Asia Pacific Center for Theoretical Physics, Pohang, Korea (Diamond, Malkov) 11/09
39. *The 19th International Toki Conference (ITC19) on Advanced Physics in Plasma and Fusion Research*, Ceratopia Toki, Toki, Japan (Diamond, Kosuga) 12/09
40. *Research and Collaboration at NFRI*, Daejeon, Korea (Diamond) 01/10
41. *DIII-D Pedestal Transport Workshop*, San Diego, CA (Diamond) 02/10
42. *CMTFO Annual Meeting*, Santa Cruz, CA (Diamond, Hsu) 03/10
43. *Nonlinear Wave Workshop 8*, La Jolla, CA (Diamond, Malkov) 03/10
44. *Hierarchical Self-Organization of Turbulence and Flows in Plasmas, Oceans and Atmospheres JIFT Workshop*, La Jolla, CA (Diamond, Hinton, Malkov, Miki, Dif-Pradalier, Kosuga, Zhao, Lee, Ulvestad) 03/10
45. *4th Meeting of Transport and Confinement ITPA Topical Group*, Culham, UK (McDevitt) 03/10
46. *CPES Meeting*, Annapolis, MD (Diamond, Hinton, Dif-Pradalier) 04/10
47. *2010 U.S. Transport Task Force Workshop*, Annapolis, MD (Diamond, Hinton, McDevitt, Miki, Dif-Pradalier, Kosuga, Lee, Zhao, Seo, Ulvestad) 04/10
48. *European Physical Society 37th Conference on Plasma Physics*, Dublin, Ireland (Malkov, Dif-Pradalier) 06/10
49. *Workshop on Electric Fields, Turbulence and Self-Organization in Magnetized Plasmas*, Dublin, Ireland (Dif-Pradalier) 06/10
50. *Research and Collaboration - HL-2A Center for Fusion Science*, Chengdu, China (Diamond) 06/10
51. *Research and Collaboration at CEA Cadarache*, St Paul lez Durance, France (Dif Pradalier) 07/10
52. *International Summer Institute for Modeling in Astrophysics Transport Processes in Astrophysics*, Santa Cruz, CA (Diamond) 07/10
53. *Research and Collaboration at University of Maryland*, College Park, MD (Malkov) 08/10
54. *Research and Collaboration at WCI NFRI*, Daejeon, ROK (Diamond, Hsu, Zhao, Kosuga) 08/10-11
55. *3rd EFDA Transport Topical Group Meeting combined with 15th EU-US Transport Task Force Meeting*, Cordoba, Spain (McDevitt, Dif-Pradalier) 09/10
56. *Research and Collaboration at Ecole Polytechnique*, Saclay, France (Diamond, Dif Pradalier) 09/10
57. *23rd IAEA Fusion Energy Conference*, Daejeon, Republic Of Korea (Diamond, McDevitt, Dif-Pradalier, Guo, Hsu) 10/10

58. *Research and Collaboration at WCI NFRI*, Daejeon, Republic Of Korea (Dif-Pradalier) 10/10
59. *52nd Annual Meeting of the APS Division of Plasma Physics*, Chicago, IL (Diamond, Malkov, Hinton, Dif-Pradalier, Kosuga, Lee, Youdin, Zhao) 11/10
60. *Research and Collaboration at WCI NFRI*, Daejeon, Republic Of Korea (Diamond, Hsu, Zhao, Kosuga) 08/10-11
61. *20th International Toki Conference (ITC-20) on the Next Twenty Years in Plasma and Fusion Science*, Toki, Japan (Kosuga) 12/10
62. *Joint Plasma Kavli Institute for Astronomy and Astrophysics*, Peking University, People's Republic of China, 01/11 (Diamond)
63. *Center for Momentum Transport and Flow Organization Annual Meeting*, New Orleans, LA (Diamond, Dif-Pradalier) 01/11
64. *2011 KSTAR Conference and KO-US Workshop*, Muju, Korea, 02/11 (Diamond)
65. *Dynamics and Turbulent Transport in Plasmas and Conducting Fluids*, des Houches, France (Diamond, Kosuga, Hsu) 02/11