CURRICULUM VITAE

UNIVERSITY OF MARYLAND

Ryusuke Numata February 12, 2008

PERSONAL DETAILS

Name : **Ryusuke Numata**
Current Position : Postdoctoral Fellow in the University of Maryland
Sex : Male
Date of birth : 30 May 1976
Nationality : Japanese
Present Address : Center for Scientific Computation and Mathematical Modeling
CSIC Building (#406)
The University of Maryland
College Park, MD 20742, USA
Tel : +1 (301) 405-0668
Fax : +1 (301) 314-6674
Email : rnumata@umd.edu

EDUCATION

March 2004	Ph.D (Frontier Science) Graduate School of Frontier Sciences, The University of Tokyo, Japan Thesis: *Nonlinear Processes in Two-Fluid Plasmas*;
March 2001	Master of Engineering (Quantum Engineering and Systems Science), The University of Tokyo, Japan Thesis: *Collisionless Magnetic Reconnection Induced by Chaotic Motion of Particles*
March 1999	Bachelor of Engineering (Quantum Engineering and Systems Science), The University of Tokyo, Japan

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PUBLICATIONS

1. “*Bifurcation in electrostatic resistive drift wave turbulence*”,
   R. Numata, R. Ball, R.L. Dewar, Phys. Plasmas **14**, 102312 (2007).
2. “*Nonlinear Simulation of Drift Wave Turbulence*”,
   R. Numata, R. Ball, R.L. Dewar, in *Frontiers in Turbulence and Coherent Structures* (World Scientific, 2007, eds. J.P. Denier and J.S. Frederiksen), pp. 431-442.
3. “Numerical analysis on the contribution of the singular perturbation by the Hall term to the spectrum of MHD turbulence using a shell model”,
   D. Hori, M. Furukawa, S. Ohsaki, R. Numata, Z. Yoshida, J. Plasma Phys. **72**, 965, (2007).
4. “*Two-fluid Nonlinear Simulation of Self-Organization of Plasmas with Flows*”,
   R. Numata, Z. Yoshida, T. Hayashi, J. Plasma and Fus. Res. SERIES **6**, 130 (2004).
5. “*Nonlinear three-dimensional simulation for Self-Organization and flow generation in two-fluid Plasmas*”,
   R. Numata, Z. Yoshida, T. Hayashi, Comput. Phys. Commun. **164**, 291 (2004).
6. “*Chaos-Induced Resistivity in Magnetic Null Region : A Nonlinear Mechanism of Collisionless Dissipation*”,
   R. Numata, Z. Yoshida, Physical Review E **68**, 016407 (2003).
7. “*Chaos-Induced Resistivity in Collisionless Magnetic Reconnection*”,
   R. Numata, Z. Yoshida, Physical Review Letters **88**, 045003 (2002).

PRESENTATION

1. “*Onset of Turbulence in a Drift Wave-Zonal Flow System*”
   R. Numata, R. Ball, R.L. Dewar, L. Stals
   Joint Conference of 17th International Toki Conference on Physics of Flows and Turbulence in Plasmas and 16th International Stellarator/Heliotron Workshop 2007, Toki, Japan (October 15-19, 2007)
2. “*Bifurcation Structures in Resistive Drift Wave Turbulence*”
   R. Numata, R. Ball, R.L. Dewar
   AIP 17th National Congress, Brisbane, Australia (December 3-8, 2006).

3. “*Bifurcation Structures in Resistive Drift Wave Turbulence*”
   R. Numata, R. Ball, R.L. Dewar
   48th Annual Meeting of Division of Plasma Physics, APS, Philadelphia, USA (October 30 - November 3, 2006).

4. “*Bifurcation Structures in Resistive Drift Wave Turbulence*”
   R. Numata, R. Ball, R.L. Dewar
   33rd EPS Conference on Plasma Physics, Rome, Italy (June 19-23, 2006)

5. “*Nonlinear Simulation of Drift Wave Turbulence*”
   R. Numata, R. Ball, R.L. Dewar
   Workshop on Turbulence and Coherent Structures, Canberra, Australia (January 10-13, 2006)

6. “*Two-Fluid Nonlinear Simulation of Self-Organization of Plasmas with Flows*”
   R. Numata, Z. Yoshida, T. Hayashi
   13th International Toki Conference on Plasma Physics and Controlled Nuclear Fusion, Toki, Japan (December 9-12, 2003).

7. “*Nonlinear Simulation of Self-Organization of Plasmas with Flows*”
   R. Numata, Z. Yoshida, T. Hayashi
   Autumn College on Plasma Physics, ICTP, Trieste, Italy (October 13 - November 7, 2003).

8. “*Self-Organization of Plasmas with Flows*”
   R. Numata, Z. Yoshida, T. Hayashi
   18th International Conference on Numerical Simulation of Plasmas, Cape Cod, USA (September 7-10, 2003).

9. “*Chaos-Induced Resistivity in Collisionless Magnetic Reconnection*”,
   R. Numata, Z. Yoshida
   Workshop on Theoretical Plasma Physics, ICTP, Trieste, Italy (2002).

10. “*Chaos-Induced Resistivity in Collisionless Magnetic Reconnection*”,
    R. Numata, Z. Yoshida
    Autumn College on Plasma Physics, ICTP, Trieste, Italy (2001).

Research and Professional Experiences

December 2007 - present	Postdoctoral Fellow in the University of Maryland
September 2004 - December 2007	Postdoctoral Fellow in the Australian National University
April 2004 - September 2004	Research Fellow (PD) of the Japan Society for the Promotion of Science
April 2003 - March 2004	Research Fellow (DC2) of the Japan Society for the Promotion of Science for Young Scientists
April 2001 - March 2003	Research Fellow of the National Institute for Fusion Science

Membership

- Physical Society of Japan
- American Physical Society

References

- **Zensho Yoshida**, Professor

Address	Graduate School of Frontier Sciences, The University of Tokyo 5-1-5 Kashiwanoha, Kashiwa, Chiba, 277-8561 Japan
Tel & Fax	+81 (4) 7136-3991
Email Address	yoshida@k.u-tokyo.ac.jp

- **Robert L. Dewar**, Professor

Address	Department of Theoretical Physics, Research School of Physical Science and Engineering, The Australian National University Canberra, ACT 0200 Australia
Phone	+61 (2) 6125-2949
Fax	+61 (2) 6125-4674
Email Address	robert.dewar@anu.edu.au

- **Rowena Ball**, Research Fellow

Address	Department of Theoretical Physics, Research School of Physical Science and Engineering, The Australian National University Canberra, ACT 0200 Australia
Phone	+61 (2) 6125-2437
Fax	+61 (2) 6125-4674
Email Address	rowena.ball@anu.edu.au

RESEARCH AREA

My primary interest is computational and theoretical studies on nonlinear phenomena in plasmas. I have been studying two-dimensional turbulence in plasmas, particle orbit chaos, self-organization of plasmas.

Quasi Two Dimensional Turbulence in Plasma and Bifurcation Phenomena

In two dimensional fluids or plasmas, an inverse energy cascade to small wavenumbers and consequent large scale coherent structures characterize difference from three-dimensional turbulence. An interaction between turbulent fluctuations and large scale structures, such as zonal flows, plays an important role in magnetically confined fusion plasma. Recent analysis of a low dimensional dynamical model by bifurcation and singularity theory predicts confinement mode transition in plasmas.

In this study, I have solved the Hasegawa-Wakatani model describing two-dimensional electrostatic resistive drift wave turbulence in plasmas, and have showed zonal flow generation and its transport suppression effect. The zonal flow generation critically depends on the electron dynamics parallel to the background magnetic field. I have also showed the transition from the zonal flow dominated to the turbulence dominated state in this system by performing a systematic parameter survey. The transition is ascribed to the Kelvin-Helmholtz instability of the generated sheared flow.

Nonlinear Mechanism of Collisionless Dissipation in Plasma

Magnetic reconnection driven by plasma flow is observed in various plasma systems such as solar flares, earth's magnetosphere and laboratory plasmas. Magnetic reconnection brings about changes in the topology of field lines, converting magnetic energy to kinetic energy. Resistivity (or magnetic diffusivity) is indispensable in the magnetic reconnection process, however, the classical (Spitzer) resistivity is too small to yield appreciable reconnection rates in high temperature plasmas. We have studied the collisionless resistivity resulting from microscopic particle dynamics, which cannot be studied by a fluid model or the Vlasov equation. In an inhomogeneous electromagnetic field including magnetic null points, particles are unmagnetized (conservation of adiabatic invariants are broken) and describe chaotic orbits. The mixing effect of chaos brings about rapid increase of the kinetic entropy, which, in the macroscopic view, yields a collisionless resistivity. In a closed system, the entropy saturate after a short time. However, in an open system where particles convect into/from a chaos region, the entropy increases locally in the chaos region, resulting in a diffusion-type dissipation.

This collisionless resistivity has been applied to explain the fast (shock-type) magnetic reconnection process. Introducing a mesoscopic model in the diffusion region, the unphysical scale reduction problem that Petschek's model encountered can be avoided.

Statistical Properties of Chaos in an Open System

The maximum Lyapunov exponent of an orbit characterizes the mean rate of divergence of neighboring orbits. In a chaotic system, it provides a quantitative measure of the degree of stochasticity. However, the conventional Lyapunov exponents defined by taking a long-time average is not applicable for an open system, because the staying time of particles is finite. To quantify the degree of stochasticity for a temporally and spatially localized chaotic phase of motion, we have improved the measure of chaos with taking an appropriate ensemble average of the temporally and spatially local Lyapunov exponents.

I am trying to develop the theory of chaos in an open system – a simple mathematical model (stadium billiard model) is used to test various characterization of chaos in an open system.

Self-Organization of Plasma with Flows

Plasma flows are considered to play an essential role in various plasmas. In fusion plasmas, the H-mode plasma is believed to be created by the shear-flow stabilization effect. In a non-neutral plasma, which has self-electric fields, strong flow generates a peculiar vortex structure. The high beta plasma in the Jupiter magneto-sphere, jets from accretion disks, or magnetic reconnections are examples of flowing plasmas.

In a flowing plasma, the Hall term brings about a nonlinear singular perturbation that enables a formation of an equilibrium with an appreciable perpendicular flows. The double Beltrami (DB) model describes essential flow-field coupling by a pair of Beltrami fields (eigenfunction of curl operator). The DB field is obtained by an appropriate variational principle invoking coercive functional and macroscopic constants of motion. To explore the accessibility and the relaxation process toward the DB fields, numerical simulation is needed.

I have developed a three-dimensional Hall-MHD simulation code on the vector-parallel supercomputer to analyze the dynamics of two-fluid plasma. With the help of numerical code, I have demonstrated the self-organization of the DB fields. Comparing withe the two-fluid relaxation with that of the single-fluid mode, an appreciable flow with a component perpendicular to the magnetic field was created. The results agree with the theoretical prediction, and highlights the difference from the Taylor relaxation in the single-fluid MHD.