Newsletter

JOINT INSTITUTE FOR FUSION THEORY

December 1988 **No. 12**

CONTENTS

The Institute for Fusion Studies (IFS) at The University of Texas at Austin and the International Center for Fusion Theory (ICFT) in Nagoya work together to form the Joint Institute for Fusion Theory (JIFT). The primary purpose of JIFT is to foster the progress of scientific research by providing a planned set of exchange visits, workshops, and computational projects that involve United States and Japanese theoretical plasma physicists working on problems associated with the development of fusion systems.

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PROPOSED 1989-90 JIFT WORKSHOPS

1. *Theoretical Problems with Non-Axisymmetric Toroidal Configurations*
   J. Johnson and G. Rewoldt (PPPL)
   M. Wakatani (Kyoto)
   (in Japan)

2. *Low-Dimensional Nonlinear Dynamics and Applications to Plasma Confinement*
   J. Cary (Colorado), J. Finn (Maryland), M. Lieberman (Berkeley)
   T. Kamimura (Nagoya), T. Hatori (Nagoya), M. Wakatani (Kyoto)
   (in USA)

3. *Field Reversed Configurations with Steady State, High Temperature Fusion Plasmas*
   D. Barnes (SAIC) and H. Momota (Nagoya)
   (in USA)

4. *Comparison of Transport Theory and Experiments in Toroidal Systems*
   K. Itoh (Kyoto) and D. Baldwin (IFS)
   (in Japan)

PROPOSED 1989-90 EXCHANGE VISITS

From US to Japan

1. *Plasma Stability Theory with High Energy Components and Alpha Particles in Fusion Plasmas*
   J. Van Dam (IFS), Visiting Professor to IPP Nagoya

2. *Rotational Instabilities of FRC System*
   L. Steinhauer (Spectra Technology), Visiting Scientist to Niigata

3. *Resistive g Turbulence*
   G.S. Lee (ORNL), Visiting Scientist to Kyoto University

From Japan to US

1. *Transport and Confinement Theory*
   K. Mima (Osaka), Visiting Professor to IFS

2. *Theory of FRC Stability and Confinement*
   A. Ishida (Niigata), Visiting Scientist

3. *Plasma Turbulence Theory*
   M. Kono (Kyushu), Visiting Scientist

PROPOSED 1989-90 JOINT COMPUTATIONAL PROJECTS

With Travel:

1. *MHD Stability and Control of a High Beta Tokamak*
   T. Takeda, T. Tsunematsu, and S. Tokuda (JAERI),
   J. Manickam (PPPL)
   (T. Tsunematsu to PPPL)

2. *Gyrokinetic Transport Simulation*
   T. Kamimura, H. Naitou, and Y. Abe (IPP, Nagoya),
   J. Dawson, V. Decyk, and R. Sydora (UCLA),
   W. Lee (PPPL)
   (R. Sydora to Nagoya and H. Naitou to UCLA)

3. *Implicit Methods for Particle Simulation Codes*
   T. Kamimura and Y. Abe (IPP, Nagoya),
   J.N. Leboeuf (ORNL), T. Tajima and A. Aydemir (IFS),
   D.C. Barnes (SAIC)
   (A. Aydemir to Nagoya)

4. *Plasma Rotation and Anomalous Transport*
   A. Aydemir, W. Horton, J. Meiss, T. Tajima (IFS),
   K. Nozaki (Nagoya University) and N. Bekki (Nihon)
   (A. Aydemir and W. Horton to Nagoya)

Without Travel:

5. *3D MHD Studies by BETA Code*
   M. Wakatani (Kyoto) and F. Bauer (NYU - Courant Institute)

6. *Theoretical and Numerical Study on Current Drive in Toroidal Systems*
   M. Okamoto (IPP, Nagoya) and M. Ono (PPPL)

WORKSHOPS -- Reports from 1988

The Joint Institute for Fusion Theory Steering Committee met in Hollywood, Florida, November 3, 1988.

Attending the JIFT Meeting were members:

US: **D.E. Baldwin** (IFS),
J. M. Dawson (UCLA),
R. Lewis (DoE) for W. Sadowski(DoE)
W. Horton (IFS).

Japan: **Y.-H. Ichikawa** (ICFT),
K. Nishikawa (HIFT),
T. Kamimura (IPP Nagoya).

The Japanese delegates were thanked for making the long trip to the American Physical Society, Division of Plasma Physics and the JIFT Steering Committee Meeting in Florida. Dr. Ralph Lewis was introduced as the representative for Dr. W. Sadowski. Then last year's JIFT exchanges were discussed and plans for the up- coming exchange year were made.

Prof. Yoshi Ichikawa described some statistics about the past eight years of JIFT activities. There have been 33 US-Japan JIFT workshops with a total number of 559 scientists participating in the workshops—171 from Japan and 388 from the US. On the average each of these scientists has participated in two JIFT workshops in the last eight years so that the total number of participants is 1127, with 463 Japanese and 664 US participants.

Review of 1988-89 Activities

Productive visits were made by Dr. Yoshi Matsuda (LLNL), Professor Ned Birdsall (UCB) (reports on their activities in this issue), and Professor M. Wakatani (IPP, Nagoya) (report in the next issue). The visits of Drs. N. Nakajima and Y. Kusano are currently in progress.

Professors Ichikawa and Kamimura reported that they have prepared the lectures given in Japan by the past eight US JIFT Visiting Professors as a volume to be published in a book.

Comments on the 1989-90 Exchange Workshops

The JIFT Steering Committee welcomed the carefully worked out proposal from Professor John Cary for a workshop on *Low-Dimensional Nonlinear Dynamics and Applications to Plasma Confinement* to be held near the University of Colorado in Boulder, Colorado. The workshop will be broad in scope, consistent with the wide range interest of his six co-organizers.

The proposers of the workshop on *Theoretical Problems with Non-Axisymmetric Toroidal Configurations* argued the need for further theoretical understanding of the two areas of (1) the nature of the magnetic surfaces and islands and (2) the collective and single particle transport properties for helical toroidal and stellarator systems. The committee felt that it would be appropriate to have this meeting in Japan in view of the start up activities of the Large Helical System (LHS) being planned at the new Toki site.

The two other workshops which the Steering Committee proposed were one on *Field Reversed Configurations with Steady State, High Temperature Fusion* and one on *Comparison of Transport Theory and Experiments in Toroidal Systems.*

A proposed schedule of workshops and exchange scientist visits for the period April 1989 to March 1990 was prepared by the committee and submitted to the US/Japan Fusion Energy Coordinating Committee (CCFE) for ratification.

Future Plans and IFR

The most dramatic development for the future in US-Japan collaboration revolves around the reorganization of the program of fusion theory and experiments sponsored by the Japanese Ministry of Education. This reorganization is currently taking place in Japan. Professor K. Nishikawa described the changes that are expected with the next budget cycle beginning April 1989, particularly as they impact fusion theory and computations. The new Institute for Fusion Research, called IFR, is being built at Toki about 40 km outside of Nagoya.

The April 89 (Showa 64) budget is expected to

be 4.7×10^9 yen ($39 million) for equipment at IFR. He described the major shifts of scientists from IPP Nagoya, from the Heliotran Laboratory at Kyoto University, and from the HIFT project at Hiroshima University to the IFR project at Toki. In addition to these shifts, there will be many new positions.

Dr. Baldwin described the shifts in emphasis that are taking place in the US fusion program especially in regard to the CIT project in Princeton and the new Transport Initiative headed by Professor Jim Callen at the University of Wisconsin.

EXCHANGE SCIENTISTS
Reports from 1987 - 88

Charles K. Birdsall
Visiting Professor

Location: IPP Nagoya
Date: August 16 - December 22, 1988

Professor Ned Birdsall from the University of California at Berkeley is the current JIFT Visiting Professor at IPP Nagoya. He has been working and lecturing on bounded plasmas and sheath dynamics using theoretical and particle simulation tools. In the first of a series of three lectures, he discussed how the time-independent theory of potential sheaths with secondary electron emission and ion reflection is tested and verified by simulation techniques. In particular, reporting on a work with L. A. Schwager, he showed how the famous Bohm pre-sheath acceleration arises from the source sheath. The second lecture discussed the problem of a 2D magnetized plasma against an absorbing wall. In this work with Kim Theilhaber, convective particle losses induced by the Kelvin-Helmholtz instability was studied. In the steady-state, large vortices drift along the wall producing Bohm-like transport. Finally, Prof. Birdsall showed the theorists how they too can solve the many-body Coulomb problem on their desk top with a PC and the Birdsall periodic ES1 code, or the bounded-plasma PDW1 code. Now, theorists can privately check their own or competitors formulas for the two-stream or the plasma-beam instability before showing them to the world!

Yoshiyuki Matsuda
Visiting Scientist

Location: HIFT, Hiroshima University
Date: March 25 - June 9, 1988

Dr. Matsuda from Lawrence Livermore Laboratory visited the Institute for Fusion Theory at Hiroshima University for two months. During his visit he collaborated with Prof. Sato and Dr. Tanaka to study Alfvén wave instabilities in a neutral-beam-driven system using particle simulation techniques. The simulations were carried out with a particle code developed by Dr. Tanaka that is suitable for studying low frequency, large scale phenomena. The motivation for the simulations was to form a better understanding of the linear and nonlinear evolution of Alfvén wave instabilities caused by super-Alfvénic beam ions in neutral-beam heated systems such as ITER. At beam populations greater than 25% of the background density, an unstable mode with the shear-Alfvén polarization was seen. The effects of this instability on the beam, and whether the mode is still unstable at more realistic beam populations, will be studied with a more refined simulation.The results obtained during Dr. Matsuda's short visit were encouraging, and he will continue his collaboration with the HIFT scientists using the US-Japan Computer Link.

Hiroshi Naitou
Visiting Scientist

Location: University of California, Los Angeles
Date: July 1 - October 16, 1987

Dr. Naitou, from IPP Nagoya, spent his three and one-half months at the University of Calfornia in Los Angeles where he collaborated with Drs. J.M. Dawson, R.D. Sydora, and V.K. Decyk in the study of advanced particle simulation with gyro-kinetic equations. He also collaborated with Drs. W.W. Lee and T.S. Hahm from Princeton Plasma Physics Laboratory. Results of this work were presented at the US-Japan Workshop on Plasma Modeling with MHD and Particle Simulations in September 25-26 at Napa, California.

A three-dimensional gyrokinetic plasma simulation model in cylindrical geometry has been developed for the purpose of investigating kinetic effects on low frequency global modes such as interchange and ideal kink instabilities. The model, which includes plasma inhomogeneity and rotational transport, is based on the gyrophase-averaged Vlasov-Poisson equations in general geometry. Briefly, the particle (electron and ion) motion is represented by the $E \times B$ drift, curvature drift, and ∇B drift in the direction perpendicular to the ambient magnetic field and by the full dynamics in the parallel direction, whereas the effect of ion polarization drift is accounted for in the gyrokinetic Poisson equation. The first application was to the simulation of drift and interchange modes with $q = 1$ rotational transform without magnetic shear. A large number (65536) of particles was traced self-consistently in a system of size $32\rho_i \times 32\rho_i \times 4000\,\rho_i$ by using a $32 \times 32 \times 32$ grid. The drift wave is most unstable in this system in the electrostatic limit. The evolution of the instability consists of two steps. First, unstable drift waves are excited. Due to the difference in the electron and ion radial diffusion caused by this instability, the plasma core region becomes negatively charged. With this radial electric field, the plasma rotates in the poloidal direction. Because the ion rotation speed is slightly slower than that of the electrons due to finite Larmor radius effects, this radial electric field can cause a secondary instability similar to the interchange instability in which $E \times B$ drift and curvature drift generate the charge separation of electrons and ions. Therefore the final state of the plasma seems to be almost identical to the structure caused by the interchange instability. In order not to excite the collisionless drift wave, the parallel electron temperature was reduced, while the parallel ion temperature was increased to enhance the growth rate of interchange modes. In this case, pure interchange modes were excited. The inclusion of the inductive parallel electric field was discussed to stabilize the drift wave and enhance the time step size in the simulation. An effort to include full magnetostatic effects is under way in order to simulate internal kink modes, etc.

MISCELLANEOUS...

The JIFT Steering Committee members are:

Professor David E. Baldwin - Director of IFS, The University of Texas at Austin
Professor John M. Dawson - University of California at Los Angeles
Professor Yoshi H. Ichikawa - Director of ICFT, Nagoya University
Professor Kyoji Nishikawa - Hiroshima University
Dr. Walter Sadowski - Chief, Fusion Theory and Computer Service, U.S. Dept. of Energy

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JIFT activities are coordinated in the US and Japan by two committees. The Japanese Management Committee consists of **T. Kamimura** (IPP)—Chairman, **T. Sato** (HIFT), **T. Takeda** (JAERI), and **M. Wakatani** (Kyoto). The US Management Committee consists of **W. Horton**—Chairman, **A. Aydemir, J-N. Leboeuf** (ORNL), **T. Tajima, P. Terry** (U. Wisconsin), and **J. Van Dam.**