MEETING REPORT

SUMMARY OF THE 11th IEEE INTERNATIONAL CONFERENCE ON PLASMA SCIENCE, ST. LOUIS, MISSOURI, MAY 14-16, 1984

Although the attendance at the 1984 Institute of Electrical and Electronic Engineers (IEEE) International Conference on Plasma Science (ICOPS) was somewhat lower than that of the 1983 ICOPS, the technical quality of all the papers presented achieved the same level of excellence established in previous years, and the plenary session review presentations were indeed exceptional. Delightful spring weather in St. Louis and an atmosphere of unity generated by the close proximity of poster boards and vendor exhibit booths resulted in a pleasant and successful meeting. Highlights of this conference, which appeals to plasma scientists and engineers engaged in a multitude of applications, are summarized in this report.

Since the Orwellian year 1984 marks the centennial of the IEEE society, Leon Shohet [University of Wisconsin (UW)] opened the conference with an exciting half hour review of the society's history, including its most distinguished members, its present status, and the considerable influence it commands on the technological direction of modern civilization. He was followed by David Nelson [U.S. Department of Energy (DOE)] who delivered the keynote address, "U.S. Magnetic Fusion—Today and Tomorrow." Nelson revealed an eye-opening picture of the official policy of the present Administration toward controlled thermonuclear fusion as a major source of energy in the future, and the approach established to achieve the goals of this policy. Audience interest stimulated by his address was evidenced by the lengthy question and answer period that followed.

Gerold Yonas' [Sandia National Laboratories (SNL)] special review paper, "Physics and Technology Requirements of the Strategic Defense Initiative (SDI)," was enthusiastically applauded by a fully attended plenary session. The objective of his talk was to define a technology development program whose immediate goal is to provide a basis for informed decisionmaking in the early 1900s as to whether to proceed with engineering prototypes of the elements of a multi-tiered defense system; directed energy weapons are one of the key building blocks of the SDI. Yonas showed a computer-generated film of Soviet missiles departing their silos and targeting selected sites in the United States that was both enlightening and thought provoking. He also offered honest technical responses to criticisms of the SDI concept.

The Wednesday morning plenary session featured guest speaker John Coburn (IBM Corporation, San Jose) on the subject, "The Role of Ion Bombardment in Plasma Etching." There is a crescendo of interest in the general field of plasma chemistry not only because of scientists' natural curiosity regarding such a wealth of unknown phenomena but also because of the industrial potential of its practical applications. Coburn gave a fascinating description, starting with the fundamentals, of the ability of "dry" plasma-based etching methods to transfer a lithographic pattern directionally, i.e., without appreciable undercutting beneath the masks used to manufacture integrated circuits.

Summaries of the various oral and poster presentations from the 22 categories of topics at this conference appear below.

MAGNETIC CONFINEMENT FUSION

Mirrors

At the session on mirrors, an invited talk on the world's mirror program and new experimental results and ideas from the mirror community (many less than 6 months old) were presented. Highlights of recent experimental results included the experimental confirmation of the axial potential profile associated with thermal barriers in the Tandem Mirror Experiment-U at Lawrence Livermore National Laboratory (LLNL), the first experimental results from Tara at the Massachusetts Institute of Technology (MIT), the first results from RFC-XX (operated as a tandem mirror) in Nagoya, and experiments at the University of Maryland on mode conversion of the drift cyclotron loss cone and at the University of Michigan on *e*-beam-assisted electron cyclotron resonance heating startup. Recent advances in superconducting mirrors in China were also presented. Highlights of recent mirror ideas consist of a design for drift pumping on Phaedrus, a study of enhancing tandem mirror plug potential by radiofrequency (rf) pumping of electrons (Interscience, Inc.), new concepts on rf interacting with plasma stability and transport [Science Applications, Inc. (SAI)-LaJolla], a study of optimization of tandem mirror coils (SAI-Boulder), and thoughts about the connection of space and laboratory plasmas (Nihon University).

Elmo Bumpy Torus (EBT)

In an invited paper, C. S. Chang reviewed the recent developments in neoclassical transport theory for EBT aimed at resolving the long-standing problem of understanding how the ions can escape from the EBT at the same rate as the electrons. Chang suggested that resonances between the poloidal and bounce motions can lead to rapid loss of low-energy ions; an analogous mechanism has been predicted in tandem mirrors. Sanuki considered the stability of the region in which the density gradient is large, that is, in the outer edge of the EBT ring. He found that the stability of this region is affected by the hot electron population as well as the ambipolar electric field.

Tokamaks — Stellarators

In the tokamak-stellarator sessions, an invited paper, "The First Year of TFTR Operation," was delivered by J. Sinnis [Princeton Plasma Physics Laboratory (PPPL)]. Contributed papers treated such subject matter as measurement of space potential and other plasma quantities by means of heavy ion beam probes in the Impurities Studies Experiment-B and RENTOR and transport of injected impurities in Heliotron-E. Stellarator and torsatron papers were related to results from the Proto-Cleo stellarator at the UW. In the tokamak area, startup and equilibrium were discussed, as were x-ray line identification in Alcator C, internal disruptions in the TEXT tokamak, and the characteristics of the tokamak edge in Doublet-III.

Toroids and Pinches

Compact toroids were covered in 10 of the 22 papers in the sessions on toroids and pinches. The presentations on field-reversed configurations (FRC) (a subclass of compact toroids) emphasized confinement and FRC translation. Evidence was presented that the plasma transport in FRCs is lower and scales differently than predicted by the lower hybrid drift instability theory. The influence of neutral particles on particle and energy losses was calculated in another study. In a present experiment, this loss channel should be relatively weak unless a fairly high background neutral density is present. The presentations on spheromaks, another subclass of compact toroids, emphasized improved diagnostics and stability. New diagnostics allowed detailed studies of magnetic field and surface current oscillations. Kink-like modes were explored; these differ from the tilt/shift family of instabilities that have been studied previously. Kink-like modes appeared to saturate and cycle and may be connected with relaxation.

Ultrafast z pinches were covered in ten papers. The principal objective was to study the potential for efficient x-ray generation in gas-imbedded z pinches. In one case, the purpose was to explore the possibilities for a simple fusion energy system. The primary emphases were (a) diagnosis of plasma parameters and the emitted radiation, (b) understanding the instabilities, and (c) exploring ways to minimize processes that limit the temperature. Two of the papers examined a novel approach to minimizing the accretion of gas that naturally occurs in a gas-imbedded z pinch, the effect of which is to limit the temperature. These experiments drew the discharge through a very narrow "capillary channel" in a solid insulator. In one case it was observed that the capillary discharge suppressed the helical instability.

In an invited talk by P. W. Hayman and J. R. Roth, a comparison between the mainline and two alternate approaches to magnetic fusion energy was presented. These results pointed out the greater physics understanding of the mainline concepts, but emphasized the potential of a much more desirable reactor product based on alternate concepts.

INTENSE ELECTRON AND ION BEAMS

The 1984 ICOPS sessions on "Intense Electron and Ion Beams," the largest single category in the conference, featured 50 papers covering light ion fusion, intense beam propagation through gases and plasmas, the high-current betatron technology, anode and cathode plasma effects in electron and ion diodes, collective acceleration, and novel power flow and particle beam accelerator concepts. The largest single subtopic was light ion fusion. The two newest additions to this session were the high-current betatron work and high-current beam propagation through gases and plasmas.

The general trend in this subject area is one toward increasingly sophisticated experiments with greatly improved diagnostics. The availability of multichannel data recording systems with gigahertz frequency response, the development of sophisticated optical and particle diagnostics, and the increasing utility of $2\frac{1}{2}$-dimensional, fully electromagnetic particle in cell simulations have greatly added to the understanding in many of these subtopics.

In light ion beam fusion, the development of time-resolved diagnostics of the focal spot has led to the adoption of aspheric anode surfaces and a significant reduction in the beam steering error. The spot size for an intense light ion beam is now 1.3-mm full-width at half-maximum from the Proto I accelerator at SNL. If this diode scales to the large multiterrawatt diode size of 15-cm radius, the focal spot is adequate for exploring inertial confinement fusion (ICF). The scaling of high-current diodes to multiterrawatt accelerators has been investigated on the PBFA-I accelerator, and high brightness beams have been obtained with these large accelerators. It was found that the purity of the ion beam was a major issue. The "proton" beams have <50% of their ions as protons. New ion sources are needed for efficient light ion drivers. The lithium ion option has been adopted for future high-voltage accelerators, and a multiphased program of ion source development was reported at the conference. In addition, Pace VanDevender (SNL) chaired a discussion panel on ion sources for light ion fusion.

The inertial fusion effort from Japan has grown considerably during the last few years. The Japanese have extensive programs in high power lasers, light ion beams, and targets. Their work with light ion beams was presented in an invited paper by C. Yamanaka [Director of the Institute of Laser Engineering (ILE), Osaka University].

Renewed interest in the propagation of intense, high-current electron beams through gases and plasmas was evident. Sophisticated experiments were reported with improved optical and x-ray diagnostics that permitted time-resolved studies of instability growth in propagating beams for the first time. The stability of the beams was addressed both experimentally and theoretically and the radiation fields from intense beams propagating in the atmosphere were theoretically studied. This research field is expected to grow in future years.

Betatrons have been used as electron beam accelerators for many years. The addition of a toroidal field to the betatron has overcome the space-charge limit in a conventional betatron. Recent experimental results at the University of

California-Irvine show that the current is ~10 000 times greater than the space-charge limit of a conventional betatron, and the energy has reached a few million electron volts, which means acceleration over $\sim 10^4$ turns. Inductive charging of modified betatrons permits the use of a very low-voltage, 100-kV injector, in contrast to the 50 MeV required for a single turn injection into a 10-kA conventional betatron.

Collective acceleration of moderate and heavy ions is a continuing interest of the intense beam community. Additional papers with both electromagnetic and plasma schemes were presented as possible avenues to achieving a high gradient, heavy ion accelerator. In addition, several novel power flow and accelerator concepts were described indicating innovation is still the cornerstone of the intense electron and ion beam community.

NEUTRAL BEAMS

Twenty-two papers were submitted to the session on neutral beams for fusion research. It is encouraging to note that the number of oral papers substantially increased this year (ten compared to four last year). Of these 22 papers, 9 papers were related to positive ion based neutral beam systems. The use of neutral beam injection in the Phaedrus and Tara tandem mirrors was described in three papers. The performance of the prototype injection unit for the JT-60 tokamak and the development and testing of the long-pulse Advanced Positive Ion Source for the Mirror Fusion Test Facility were reported by the Japanese Atomic Energy Research Institute, Lawrence Berkeley Laboratory (LBL), and Oak Ridge National Laboratory (ORNL) groups, respectively. This year, a sizable number of papers were related to negative ion production and acceleration systems. The operation of surface-production-type negative ion sources, volume-produced hydrogen, and the Transverse Field Focusing accelerator design were described. The use of negative ion-based neutral beam systems in future mirror facilities was also presented in one paper. The only invited paper in this session was given by Klaus Berkner who described the present status of the Neutral Beam Engineering Test Facility at LBL.

FUSION TECHNOLOGY, THERMIONICS, AND MAGNETOHYDRODYNAMICS (MHD)

This was a combined session incorporating magnetofluid dynamics, thermionics and plasma diodes, and fusion reactor technology. Two papers in magnetofluid dynamics were presented. The first discussed secondary flow in an MHD channel. Experimental measurements, using laser Doppler anemometry, of the transverse flow field were presented. Results showed that the secondary flow field is characterized by large-scale vertical structures. The second paper presented a variational method for analysis of compression of dense plasmas. This treatment implies a minimum rate of dissipation of energy and gives the perturbation spectrum.

Four papers dealing with thermionics and plasma diodes were presented. The first concerned laser-heated, cesium-coated thermionic cathodes for use in free electron lasers. Current densities of up to 30 A/cm^2 with rise times under 40 ns were reported for a diode with 0.50-cm spacing and 20-kV applied voltage. Plasma closure rates were reported to be 0.15 to 0.40 cm/μs. The second paper, which was an invited paper, dealt with a statistical mechanical model of oxygen and cesium coadsorption on thermionic electrode surfaces, and the effect on surface work function. This model includes all atomic, molecular, and ionic species that can arise due to interactions or transitions on the surface or in the vapor. The third paper dealt with phenomena in the emitter sheath of a thermionic diode. Ion reflection, ion trapping, and surface ion emission were included. It was found that these phenomena significantly increase loss mechanisms at low currents. The fourth paper discussed the effects of ion trapping in thermionic converters operating in the Knudsen regime.

Four papers were presented dealing with fusion reactor technology. The first paper discussed the results of a Monte Carlo study of inhomogeneities in the breeding blanket. It was found that the inhomogeneities expected in current design trends significantly depress the tritium breeding ratio and the energy deposition and increase the neutron leak. The second paper discussed the design of the protection system for the Big Dee vacuum vessel to be installed in Doublet-III. The third paper presented the results of a design and cost study of the FIRST STEP facility, an ICF facility to produce tritium, special nuclear materials, and electric power. The last paper summarized the status of laser-pellet fusion, discussing improved laser technology and deuterium-tritium (D-T) pellet design.

PLASMA FOCUS AND NUCLEAR-PUMPED LASERS

The study of the plasma focus is regaining its popularity partly because of significant advances in plasma diagnostics that make greater understanding of this dynamic, high-energy density plasma possible, and because the properties of the plasma make the plasma focus an attractive candidate for several applications. Eighteen papers were presented (including two invited papers) in two oral sessions by scientists from six countries (Argentina, Federal Republic of Germany, Italy, Poland, United Kingdom, United States), making it a truly international session.

There were three major "themes" to the papers presented:

1. plasma dynamics and diagnostic techniques
2. beam diagnostics and acceleration mechanisms
3. applications (notably as a photon source for pumping lasers and as an opening switch).

However, considering the fundamental nature of item 1, there was considerable overlap between it and the other themes. The Tuesday afternoon session was devoted mainly to theme two above (beams) and H. Krompholz (University of Darmstadt) presented an invited talk on his work and that of his colleagues. He described the development of unique diagnostics (Schlieren mode locked laser, infrared emission, and Cherenkov *e*-beam detector) and the comparison of the experimental results with a coherent nonlinear model for plasma dynamics and beam acceleration. The Wednesday morning session included papers on all these themes and was highlighted by an invited talk presented by N. J. Peacock [Culham Laboratory (CL), United Kingdom]. The work of Peacock and his colleagues involved the thorough study of laser scattering by the plasma focus during the collapse, compression, and beam phases of the pinch. The results were compared with a theoretical model, which included strong drifts and turbulence, the latter probably caused by electron beams and instabilities. Although limited space permits only discussion of the invited talks, several of the contributed papers were comparable to the invited talks in quality, making the sessions very interesting and the selection of the invited papers very difficult.

The "Nuclear Pumped Laser" session, chaired by Mark S. Zediker (McDonnell Douglas Corporation), included nine oral presentations. In his invited overview paper, M. A. Prelas [University of Missouri-Columbia (UMC)] discussed the possibility of developing very high-powered nuclear-pumped lasers using dual media concepts to separate the pumping and lasing volumes. Several unique approaches to improved reactor coupling include the use of a fluidized-bed (aerosol)-type reactor using micron-sized uranium pellets. In a series of papers, M. Zediker and H. E. Elsayed-Ali and G. H. Miley [University of Illinois (UI)] discussed recent studies of a nuclear-pumped singlet-delta oxygen system for driving an iodine laser. In one paper, they proposed the formation of ozone by irradiation of high-pressure noble gas/oxygen mixtures. A KrF nuclear-pumped flashlamp is then used to decompose the ozone, efficiently forming singlet-delta oxygen. Generation of singlet delta was also explored using a hybrid irradiation electrical discharge cell. One advantage of this approach is the possibility of achieving a low electrical field to number density ratio, which is most favorable for singlet-delta production by electron collisions. The remaining papers were concerned with various aspects of nuclear-pumped flashlamps. These devices are of interest because a high intensity and efficiency appear possible using select fluorescence, especially with the various excimers. D. Shannon (UI) described a unique ray tracing program designed to optimize the optics of such systems. Several researchers from the UMC (A. Chung and M. Prelas et al.) discussed experimental and theoretical studies of excimer fluorescence in these situations.

ELECTROMAGNETIC AND PLASMA WAVES

During the past several years, a strong resurgence of interest has been observed in vacuum electronics. The wide range of topics covered within and the substantial increase in papers contributed to the "High Power Microwave and Submillimetre-Wave Generation" sessions are indicative of this trend. Substantive progress has been made in the study of new concepts for the generation of coherent radiation over a frequency range that extends from 1 GHz to well in excess of 100 GHz. The span of operational parameters gives rise to output microwave powers that range from a few watts to fractions of a gigawatt.

Of the topics considered, fast wave devices and concepts for the exploitation of intense relativistic electron beams remain as the primary centers of interest. The variety of fast wave device concepts under study is extensive. Work has been reported on such gyro-devices as the high-power gyrotron for fusion heating, the quasi-optical gyrotron, the gyro-klystron and the high harmonic cusptron or gyro-harmonitron. Of particular note are the design studies and initial development underway at Hughes and Varian to develop 100-GHz gyrotrons capable of producing continuous power at 1 MW for the DOE fusion heating program. In addition, the successful operation of the University of Maryland cusptron device at the sixth harmonic of the cyclotron frequency is a significant accomplishment. The study of the free electron laser (FEL) is similarly wide in scope, with research on such devices as the rippled field magnetron, the Ubitron, and FEL being reported. Recent theoretical analysis of gyroresonant and three-dimensional effects, which are important in FEL/Ubitron operation at millimetre wavelengths, was presented in an invited paper. Using the results of this analysis, a high-gain millimetre-wave-free electron laser was designed at the Naval Research Laboratory. The first operation of this device as a true amplifier rather than a noise amplifier was reported.

As reported at this conference, intense relativistic electron beam research was concentrated on virtual cathode oscillators (vircator) reflect triodes, relativistic backward wave oscillators (BWOs), and cusp-injected devices. Peak microwave powers of ~0.5 GW were demonstrated by researchers at the University of Maryland, the SNL, and LLNL using rotating electron layers, the relativistic BWO and the vircator, respectively. Noted as a trend is the increasing use of sophisticated numerical simulation codes to predict the performance of microwave devices. The use of these techniques now includes conventional as well as intense beam devices.

In the session on "Plasma Waves, Instabilities and Antennas," topics ranged from rf heating of fusion plasmas to basic plasma physics questions, such as radiation from plasma-loaded antennas and nonlinear wave generation and propagation. In the oral session, three papers dealt with rf heating topics, including an invited paper by J. Scharer et al. (UW) describing recent developments in the high-power rf heating program on the Joint European Torus device in the CL. Hsuan et al. (PPPL) covered the recent electron cyclotron heating results from the Poloidal Divertor Experiment tokamak while the work of McVey (MIT) treated the ion cyclotron heating problem in magnetic mirror geometry. Three papers in this session dealt with aspects of electron beam interaction with plasma, one on plasma-coated antennas and one on harmonic generation in isotropic plasmas.

In the poster sessions, two papers dealt with Alvén wave generation and plasma heating. Two other papers were concerned with antenna design and performance in the presence of plasma. Three papers were given on rf aspects of electric field dominated discharges and two others considered the effect of waves on confinement in fusion devices. Several papers were given concerning double layers and nonlinear wave phenomena. One paper treated the general invariant properties of the plasma wave theory and two papers were concerned with particle simulation of plasma phenomena.

PLASMA DIAGNOSTICS

Twenty-three papers were contributed under the category of plasma diagnostics. All papers were presented in two poster format sessions. In addition, one invited talk by Jim Chang (SNL) was presented on the subject of multichannel recording under the subject category, "Intense Electron and Ion Beams." This very interesting talk dealt with the subject of using a fast streak camera recording of a multielement array of fiber optics to achieve economical and high band width recording of fast transient events.

Eleven of the contributed papers were presented in the general area of particle diagnostics:

1. neutron diagnostics (2 papers)

2. heavy ion probe diagnostics (5)

3. neutral time-of-flight diagnostic for ion temperature measurements (1)
4. fast particle effects on radiation losses (1)
5. Thomson spectrometer resolution analysis (1)
6. time-resolved pinhole camera for intense proton beam focus measurements (1).

Nine of the contributed papers were presented in the general area of infrared, optical, and x-ray diagnostics. These included

1. infrared camera/foil bolometer measurement of power deposition (1 paper)
2. resonance Rayleigh scattering on a barium plasma (1)
3. x-ray spectroscopy (2)
4. x-ray framing camera (1)
5. laser interferometry (3)
6. measurement of large currents using the Faraday rotation effect (1).

Finally, three papers were contributed in the area of data recording and computer techniques. Two of these papers dealt with high-speed multichannel data recording using a fiber-optic-streak camera recording of pulse power accelerator data, and one dealt with computer-aided reduction of plasma data.

LASER/PLASMA INTERACTIONS

In a session of six invited papers, speakers from Canada, Japan, the United Kingdom, and three U.S. laboratories described recent developments in high-power laser interaction research.

S. J. Gitomer (Los Alamos National Laboratory) described initial experiments on absorption, fast ion losses, and hot electron scaling carried out with the recently commissioned Antares laser. This 24-beam CO_2 laser has produced 1-ns pulses on target with a 20-kJ energy. With a focal spot diameter of 200 μm, intensities in the 10^{15} to 10^{16} W/cm^2 range can be generated. A second paper on CO_2 laser interactions was presented by H. A. Baldis [National Research Council (NRC) of Canada] who described the application of Thomson scattering techniques to identify and study electron plasma waves and ion waves driven by various instabilities, such as stimulated Raman scattering and stimulated Brillouin scattering in the plasma corona.

The remaining papers described experiments being carried out with glass lasers. R. P. Drake (LLNL) reported on a series of studies being carried out with several kilojoules of green light from the Novette laser system to study interaction processes in large scale length plasmas. Stimulated Raman scattering appears to be particularly important with Raman yields and hot electron fractions in excess of 1% being measured.

A paper describing the recently completed Gekko XII laser was presented by Y. Kato (ILE). This 12-beam glass laser achieved a peak power of 50 TW in a 100-ns pulse and is also designed to provide an output energy of 20 kJ in a 1-ns pulse. Initial implosion experiments were carried out with various types of cannonball targets, and maximum D-T neutron yield of 4×10^{10} was observed with 25 TW of irradiating laser power.

Recent experiments carried out at the Central Laser Facility, Rutherford-Appleton Laboratory, United Kingdom, were described by J. D. Kilkenny (Imperial College, London). The six-beam facility provides 1 kJ at 1.06 μm and 0.5 kJ at 0.53 μm, and recent studies have emphasized thermal conductivity and hydrodynamic instabilities. Thermal conductivity experiments indicate a heat flux up to 10% of the free streaming limit and no "foot" to the temperature front. Compression experiments at 0.53 μm were diagnosed by x-ray backlighting and densities of $\sim 10\ \mathrm{g \cdot cm^{-3}}$ were recorded for moderate aspect ratio targets.

Compression studies with shorter wavelength radiation are being carried out at the Laboratory for Laser Energetics, University of Rochester, and R. L. Keck described the first experiments in spherical geometry performed with six beams of the OMEGA Nd:glass laser converted to the third harmonic. This laser system can now provide 250 J of 351-nm radiation on spherical targets at intensities up to 2×10^{15} W/cm^2. Absorption of 85%, dominated by inverse bremsstrahlung, was measured at an irradiation level of 5×10^{13} W/cm^2, and studies of electron energy transport indicate that ablation pressures of ~ 100 Mbar are generated at intensities of 10^{15} W/cm^2.

An additional nine papers were presented in an accompanying poster session, which covered such topics as soft x-ray generation, "beat wave" acceleration, energy loss rate of fusion products, and stabilization of Rayleigh-Taylor instabilities.

ARC TECHNOLOGY, GASEOUS ELECTRONICS, ION BEAMS, AND MASS ACCELERATORS

"Arc Technology and Gaseous Electronics" included a variety of subjects related to gas discharge plasmas. The subjects ranged from fundamental collisional processes to characteristics of specific devices or applications. The types of discharge plasmas included vary from low-pressure glows to high-pressure arcs, from transient to steady state, and from dc electroded to high-frequency electrodeless. The contributions in 1984 reflected the intended variety in this subject category; they included papers on low- and high-pressure microwave plasmas, breakdown, circuit-breaker arcs, laser discharges, and discharge switches.

The session on "Ion Beams and Mass Accelerators" was a somewhat diverse collection of papers. The common thread was their application of plasma technology for a particular end use. The ion beam papers were directed toward problems of high current implantation. They covered pulsed and steady-state systems, ion sources, and system operating problems. The mass accelerator papers discussed design problems of rail guns, experimental results, and applications to particular uses, such as fuel pellet injection.

COMPUTER METHODS

Six papers were submitted to the session, "Computer Methods." They included a steady-state ionization balance model for nonequilibrium high-density plasmas by Y. T. Lee (LLNL), including the effects of collisional excitation and de-excitation, radiative emission, collisional ionization, radiative recombination, three-body processes, and dielectronic recombination. S. E. Attenberger et al. (ORNL) described a new and efficient mapping algorithm between flux coordinates and real-space coordinates for toroidal plasmas. This algorithm is especially useful because theoretical calculations are conveniently done in flux coordinates while the evaluation of data is performed in real space so that the ability to rapidly transform between the two representations is essential.

A. Mankofsky et al. (SAI) presented a paper on ARGUS, which is a three-dimensional plasma simulation model. The ARGUS code contains a particle-in-cell treatment, full electromagnetics, and a hybrid fluid code within a common framework. T. N. Agrawal (HBTI, India) and R. P. Gupta (NRC, Canada) described a three-dimensional element model for the calculation of transient magnetic fields in the transitional region of a transmission line. L. A. Lerche (LLNL) described an automated "electronic shot book" for cataloging and manipulating data for on-line computer storage and retrieval.

F. J. Rogers and H. E. Dewitt (LLNL) presented a new method for determining a thermodynamically consistent treatment of multicomponent plasmas by deriving a hybrid integral equation that contains a single disposable parameter.

A complete set of Abstracts (IEEE Publication No. 84CH1958-8) from the conference is available from the IEEE, 345 E. 47th Street, New York, New York 10017.

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