GROUND-BREAKING CEREMONY

FOR

ENERGY RESEARCH BUILDING

ADDITION

July 19, 1979

GROUND BREAKING CEREMONY

July 19, 1979

3:30 p.m.

Master of Ceremony — Dr. Chuan Sheng Liu

Welcome: J. S. Toll, President, University of Maryland

R. Gluckstern, Chancellor, University of Maryland

Speaker: Edwin E. Kintner, Director
Office of Fusion Energy
Department of Energy

Remarks: Melvin Gottlieb, Director
Princeton Plasma Physics Laboratory

Harry Woolf, Director
Institute for Advanced Study

Frank Kerr, Provost
MPSE Division
University of Maryland

Introduction to the Program of the Laboratory for Plasma & Fusion Energy Studies — Dr. Chuan Sheng Liu, Acting Director

Ground Breaking

4:30 p.m. Tour of present Energy Research Building

4:50 p.m. Buses leave for Rosborough Inn

5:00-6:00 p.m. Reception (Rosborough Inn)

ENERGY RESEARCH BUILDING - NEW ADDITION

The new facility will provide research laboratories and offices for the Plasma and Fusion Studies Program. 35,000 square feet of new space will be in the new addition at a cost of approximately $2,700,000. The building has been designed to handle the unique laboratory space that this research requires such as very heavy floor loadings, high capacity electrical service, constant temperature and humidity control, high ceilings, etc.

This new space is essential to meet the needs of the rapid expansion of the plasma physics, fusion energy effort as well as collective accelerator studies at the University of Maryland. It will foster collaboration and promote more cohesiveness for the program since researchers who are presently split between several different buildings will be housed in the same building. Logistical support for the group will be simplified and less costly.

The expert and diligent work of Clas, Riggs, Owens and Ramos, the architect, was very much appreciated. They were very responsive to the special facility requirements that were given them. The general contractor for the building is Kora and Williams.

LABORATORY FOR PLASMA AND FUSION ENERGY STUDIES

Faculty

A. W. DeSilva, Professor (SS 3104)

H. R. Griem, Professor (on sabbatical)

D. Koopman, Research Professor (SS 2227)

H. Lashinsky, Research Professor (SS 3215)

Y. C. Lee, Professor (SS 3203)

C. S. Liu, Professor (SS 3101)

E. Ott, Professor (SS 3213)

K. Papadopoulos, Professor (SS 3213)

M. P. ~~Riser~~ Reiser, Professor (Z 4319)

D. Tidman, Research Professor (SS 4227)

C. S. Wu, Research Professor (SS 3251)

D. A. Boyd, Associate Professor (SS 0237)

G. C. Goldenbaum, Associate Professor (SS 3102)

T. McIlrath, Research Associate Professor (SS 4227)

M. Rhee, Associate Professor (Martin Engr. Bldg.)

H. H. Chen, Assistant Professor (SS 3223)

W. Destler, Assistant Professor (Martin Engr. Bldg.)

C. D. Striffler, Assistant Professor (Martin Engr. Bldg.)

M. Blaha, Senior Research Associate (SS 3105)

C. A. Chin-Fatt, Senior Research Associate (ERB 0140)

J. F. Drake, Senior Research Associate (SS3103)

N. T. Gladd, Senior Research Associate (SS 3225)

S. Goldstein, Senior Research Associate (SS 0233)

J. U. Guillory, Senior Research Associate (SS 3223)

A. D. Krumbein, Senior Research Associate (SS 3203)

P.K. Chaturvedi, Research Associate (SS 3255)

J. Y. Choe, Research Associate (SS 3225)

Y. P. Chong, Research Associate (ERB 0133)

R. U. Datla, Research Associate (ERB 0123)

P. Guzdar, Research Associate

A. D. Hassam, Research Associate (SS 3257)

R. A. Hess, Research Associate (ERB 0143)

R. Mahon, Research Associate (SS 3223)

A. Marotta, Visiting Research Associate (ERB)

B. Melander, Research Associate (SS 3255)

W. NamKung, Research Associate (EE)

H. Rowland, Research Associate (SS 3257)

F. Stauffer, Research Associate (SS 0235)

A. Sternlieb, Research Associate (SS 0233)

G. Tait, Research Associate (SS 0233)

V. K. Tripathi, Research Associate (SS 3255)

D. Winske, Research Associate (SS 3105)

The Laboratory for Plasma and Fusion Energy Studies, as a unit in the Division of Mathematical and Physical Sciences was formed last year to further strengthen the research in plasma physics, accelerator and fusion energy studies and to foster interdisciplinary cooperation. The Laboratory has about 50 Ph.D. scientists - 13 Professors, 4 Associate Professors, 4 Assistant Professors, 7 Senior Research Associates, 22 Research Associates and 28 Graduate Students; 8 Technicians and 7 Staff Members.

Ongoing research work includes all important areas of plasma physics; magnetic fusion, laser fusion, intense electron and ion beam physics, space and astro plasma physics, nonlinear phonomena and computer simulations of plasmas. Research is supported by grants and contracts from various agencies, Department of Energy, National Science Foundation, Office of Naval Research, AFOSR and NASA, of about $2.5 million/year.

Since 1966 the University of Maryland and the U. S. Naval Research Laboratory have had a very fruitful Joint Program for Plasma Physics, a program that has significantly expanded the scientific breadth of all participants and maximized the utility of the laboratory facilities. This program helped to lay a strong foundation for the Plasma Physics Program at Maryland, a program that has almost tripled in size in the last thirteen years.

EXPERIMENTAL PROGRAM

Cyclotron Radiation Studies

In 1975 the University of Maryland Group began their collaboration with the Princeton Plasma Physics Laboratory in a series of experiments on the ATC Tokamak. This collaboration proved so successful that they were invited to join the diagnosticians preparing for the PLT experiments and in 1976 the first measurements were performed. Between the ATC and PLT they made a brief visit to MIT for a series of measurements on the Alcator Tokamak. Pioneering work with a grating spectrometer has led to a notable new plasma diagnostic instrument found invaluable in the highly successful neutral beam heating experiment of last summer. A Michelson Interferometer System, first introduced by Costley in England, has been developed to be the most powerful such system in existence producing over 30 electron temperature profiles per discharge. Currently the Maryland Group is developing systems for the TFTR Project building grating spectrometers for PDX and Doublet III and beginning experiments on Mirror Machine and EBT.

PS-1 (Paramagnetic Spheromak)

The spheromak is a new class of controlled fusion, magnetic confinement experiments which it is hoped will allow a smaller, simpler and cheaper reactor to be built. PS-1 is the first controlled fusion experiment to produce this configuration.

The spheromak takes its name from a combination of spheroidal and tokamak. It is a toroidal configuration but without a field Producing coil structure through the center of the torus. PS-1 is a prolate spheroid (i.e. shaped like a football). Because the toroidal field is produced by plasma currents, rather than a metallic conductor through the center of the toroid, it can be a very compact torus leading to economies.

The Spheromak program has three phases: 1) Study of methods of producing the configuration; 2) Short term instability investigations and 3) Long term stability and transport studies. The present experiment PS-1 is in the first stage of this program. We have produced spheromak equilibria using pulsed power pinch techniques and are surveying possible regimes of operation. Later this summer the necessary electrical equipment will be installed to study the stability of the equilibria. Finally long term stability and transport will be studied starting next fall when additional computer banks are installed.

TERP II

Terp, an acronym for Toroidal Experimental Research Plasma, is an experiment designed to produce and study pressure driven and resistive instabilities in toroidal plasmas.

In any controlled fusion reactor relying on magnetic confinement it is important to maximize the confined particle pressure for a given applied magnetic field. The parameter describing this is beta ($\beta = 2p/B^2$). In the tokamak a value of β of 0.1 to 0.2 is necessary to make an economically usable reactor. In the present generation of tokamaks, for which $\beta < 0.1$, magnetically driven instabilities have limited the operating regime. As beta increases, the thermal energy (as well as the magnetic energy) becomes a nonnegligible source of free energy to drive instabilities. It is suspected that pressure driven instabilities may determine the β limit at which tokamak reactors may operate. Recent theoretical developments have indicated that there may be a β region of instability above and below which the plasma is stable against pressure driven modes.

In Terp II we are investigating these instabilities to determine the beta limits. Terp in a noncircular (rectangular) cross section torus with small aspect ration ($\Omega/a \simeq 2$). Unlike conventional tokamaks which strive for long lived slowly varying fields Terp uses a much more economical and efficient pulsed power technology to produce high beta equilibria for pulse times just long enough to observe the instabilities. Previously, in Terp I, we studied the beta limits of the magnetically driven kink mode by comparing experimental data with computer simulations of the plasma. We expect to do this type of comparison with computer experiments in the present version of Terp also. In addition to understanding relevant instabilities this approach increases the level of confidence in the large complex codes used to design fusion experiments.

Reversed Field Theta Pinch

A reversed field theta pinch utilizes an initial magnetic field that is anti-parallel to the direction of the main magnetic field of the theta pinch. The result of this is that the magnetic field lines break and recombine in such a way that they form a toroidal system. Thus, a closed magnetic field configuration is formed that can confine a plasma longer than is possible with the open field line configuration of a normal theta pinch.

Recent experiments have shown that the plasma produced is stable for a longer time than present theory predicts. In our experiment, the plasma breaks up and is lost in a few microseconds, probably due to a tearing instability. What we hope to accomplish with this experiment is to study the creation, development and destruction of the reversed field plasma, and hopefully, to extend its lifetime.

Implosion Heating of a Plasma in Thor

Thor is a high-power ($\lesssim 10^{12}$W), pulsed ($\sim$ 1 μsec rise time), high voltage ($\lesssim$ 600 kV) toroidal θ pinch (20 cm minor radius, 50 cm major radius). To provide an equilibrium at least for the initial plasma, a toroidal current is provided, as is an initial toroidal bias field. Superimposed on this bias field is a ringing preheater θ discharge, which together with the toroidal current generates the initial plasma for the implosion experiments. The main θ pinch current is crowbarred near its peak with an L/R time of $\sim$ 30 μsec.

The experiment serves two purposes, the investigation of micro-instability and other implosion heating mechanisms in the absence of rapid energy losses along open field lines, and the exploration of the compatibility of fast pinch heating with toroidal confinement.

Magnetic probe measurements after the implosion give toroidal and poloidal field distributions consistent with calculated MHD equilibria. With a fill pressure of $\sim$ 2 mTorr Deuterium, the implosion heating leads to densities of $\lesssim 10^{15}$ cm^{-3} and ion temperatures of 1-2 keV, depending on the theta pinch voltage. A small population of hit electrons is observed to have 4-8 keV temperatures throughout the plasma.

Accelerator Research Group

The accelerator Research Group is engaged in experimental and theoretical studies of collective ion acceleration, microwave generation by intense relativistic rotating electron beams, and inertial confinement fusion with heavy ion beams.

The facility used for collective acceleration and microwave studies in a high-power electron beam generator, which produces 30 ns electron pulses with peak energies of 3 MeV and peak currents of 40 kiloamperes. For studies of collective ion acceleration using an electron ring (ERA) and of microwave generation, a short, rotating E layer or electron ring with 10^{12} to 10^{13} particles is formed by injecting a hollow, cylindrical electron beam through a magnetic cusp. At these high electron densities, the "negative-mass" instability produces high-power microwave radiation at harmonics of the cyclotron frequency. For ERA application, this instability is suppressed and studies related to the properties of the E layer are pursued. For microwave generation, we are studying processes that enhance the instability and the coherence of the associated electromagnetic radiation.

Future studies are aimed at acceleration of heavy ions. The heavy-ion fusion studies are concerned with the problem of transporting space charge dominated intense beams through long focusing channels and using a collective accelerator as an ion source and injector for a heavy-ion fusion facility. Collective ion accelerators promise to overcome the severe current limitations of heavy-ion fusion accelerators at low energy.

The Accelerator Research Group involves the collaboration of four faculty, three Research Associates, and nine graduate students from the Electrical Engineering Department and the Department of Physics and Astronomy.

Theory Group

All these experiments are in close collaboration with the plasma theory group in the Department of Physics and Astronomy, which has 17 Ph.D. physicists including three professors and one assistant professor. Theoretical work includes fundamental plasma processes and nonlinear plasma behaviors, small and large amplitude waves, equilibrium and stability of confined plasmas, radiations and transports, laser-plasma interaction and beam-plasma interactions.

LIST OF PARTICIPANTS

Carol Arsenault, Staff, Plasma Group, University of Maryland

Dr. Arden Bement, Director, Material Sciences, ARPA

Dr. M. Blaha, Senior Research Assoc., Univ. of Maryland

Thomas Blair, Student, Univ. of Md.

Dr. Steve Bodner, Research Scientist, Naval Research Laboratory

Dottie Brosius, Staff, Plasma Group, University of Maryland

Lorraine Calobong, Staff, Plasma Group, Univ. of Maryland

Dr. Christine Celeta, Vis. Asst. Prof., Univ. of Maryland

Chia-Lie Chang, Grad. Res. Asst., Univ. of Maryland

Dr. H. H. Chen, Research Associate, Univ. of Maryland

Dr. C. Chin-Fatt, Research Assoc., Univ. of Maryland

Dr. Y. P. Chong, Research Associate, Univ. of Maryland

Dr. Robert A. Corrigan, Provost, University of Maryland

Rose Crowe, Staff, University of Maryland

William Crowe, Technician, Plasma Group, Univ. of Maryland

Eugene Day, Electrical Engineer, Plasma Group, Univ. of Maryland

Florence Decker, Staff, Plasma Group, Univ. of Maryland

Dr. J. F. Decker, Director of Div. of Applied Plasma Physics, DOE

Kenneth Diller, Technician, Plasma Group, Univ. of Maryland

Dr. W. Destler, Professor, Elec. Engr., Univ. of Maryland

Dr. Richard Ellis, Asst. Professor, Univ. of Maryland

Robert Esposito, Director of Planning, Univ. of Maryland

Dr. George Funaro, Provost, University of Maryland

Leon Gaither, Student, University of Maryland

Dr. Nevel Gladd, Senior Research Associate, Univ. of Maryland

Dr. Harold Glaser, Program Director, Solar-Terrestial Physics, NASA

Dr. Robert Gluckstern, Chancellor, University of Maryland

Dr. Jeffery Golden, Research Scientist, Naval Research Laboratory

Dr. Nancie L. Gonzalez, Vice Chancellor, University of Maryland

Dr. M. Gottlieb, Director, Plasma Physics Laboratory, Princeton Univ.

Dr. Donald S. Gross, Asst. Dean, Coll. of Engr., University of Maryland

Dr. John Guillory, Research Associate, Univ. of Maryland

Charles Hall, Student, University of Maryland

Dr. Robert O. Harger, Professor and Director, Elec. Engr., Univ. of Maryland

LIST OF PARTICIPANTS CONTINUED

Monica Harris, Student, University of Maryland

Dr. Adil Hassam, Research Assoc. University of Maryland

Dr. Roger Hess, Research Associate, University of Maryland

Karrol Hudson, Technician, Plasma Group, University of Maryland

Dr. James Irby, Research Associate, University of Maryland

William K. Jenne, Research Coordinator, Plasma Group, Univ. of Maryland

Dr. Robert E. Kendig, Director of Facil. & Planning, Univ. of Maryland

Dr. Frank Kerr, Provost, University of Maryland

Edwin E. Kintner, Director, Office of Fusion Energy, DOE

Harry Kriemelmeyer, Director of Facilities, MPSE, Univ. of Maryland

Diana Kriemelmeyer, Student, University of Maryland

Dr. A. Krumbein, Visiting Senior Research Assoc., Univ. of Maryland

Dr. Mukul R. Kundu, Chairman, Astronomy Program, Univ. of Maryland

Sharon LaMoure, Student, University of Maryland

Dr. H. Lashinsky, Professor, IPST, Univ. of Maryland

Dr. Y. Y. Lau, Visiting Scientist, Mass. Institute of Technology

Bernard Leikind, Grad. Res. Assistant, University of Maryland

Dr. Chuan S. Liu, Acting Director, Lab. for Plasma & Fusion Energy Studies
Univ. of Maryland

Dr. R. Mahaffey, Research Scientist, Naval Research Laboratory

Richard Majeski, Student, University of Maryland

George Marklin, Grad. Res. Assistant, University of Maryland

Mr. McCord, General Services of the State of Maryland

N. McNelis, Grad. Res. Assist. University of Maryland

Victor Medina, Director, Sponsored Programs, Univ. of Maryland

Robert Merlino, Grad. Res. Assist., University of Maryland

David Miller, Technician, Plasma Group, Univ. of Maryland

James Myra, Grad. Res. Assist., University of Maryland

John Peregoy, Student, University of Maryland

William C. Perna, Architect, University of Maryland

Tony Ramos, Architect, Clas, Riggs, Owens & Ramos

S. Riyopoulos, Grad. Res. Assist., University of Maryland

Dr. M. J. Rhee, Assoc. Professor, Elec. Engr., Univ. of Maryland

Larry Schaftner, Contractor, Kora and Williams

Sibylle Sampson, Administrator, Dept. Operations, Physics & Astronomy
Univ. of Maryland

LIST OF PARTICIPANTS CONTINUED

Dr. Joseph Silverman, Director of IPST, University of Maryland

Richard Smith, Physics Purchasing, University of Maryland

Robert Smith, Vice President, University of Maryland

Dr. Phillip Stone, Chief, Experimental Plasma Research Branch, Div. of Applied Plasma Physics, DOE

Dr. John S. Toll, President, University of Maryland

John Wall, Mgr. of Purchasing, University of Maryland

Bruce Weber, Res. Grad. Assist., University of Maryland

Elizabeth White, Student, University of Maryland

Dr. Dan Winske, Research Associate, University of Maryland

Susan Wolman, Student, University of Maryland

Dr. Harry Woolf, Director, Institute for Advanced Study

Dr. C. S. Wu, Research Professor, IPST, University of Maryland