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DEPARTMENT OF APPLIED PHYSICS
AND NUCLEAR ENGINEERING

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Subject: Quarterly Status Report: High-Beta Tokamak Research
EY-76-S-02-2456

Period Covered: 1 October through 31 December 1978

1. ACTIVITY

A. Torus 2:

(P.G. Weber, G. Georgiou, C. Kostek, A. Kashani, G.A. Navratil,
T.C. Marshall, R.A. Gross)

Two dimensional streak photography has clearly shown that during the heating phase, the plasma experienced a downward motion and at about 8 $\mu\text{sec.}$, it came in contact with the bottom glass surface. Visible light spectroscopy indicated at this time a sudden cooling. Magnetic field mapping confirmed this problem, and indicated that the cause of this lack of vertical equilibrium was due primarily to an unfavorable radial component of magnetic field curvature. Changes were made in the external vertical field coil spacing to improve the field curvature, and a set of new, passive, shorted hoop coils were installed. These changes have solved this problem beautifully and vertical plasma positioning is now excellent.

An estimate of the plasma toroidal beta is $\sim 10\%$; this value is obtained from the radial equilibrium provided by the external vertical magnetic field. It is consistent with previous estimates made from temperature, density and magnetic field measurements. We intend to make these measurements of β more precise, as soon as possible.

Some progress has been achieved in developing a magnetic probe system capable of sustaining its integrity during high voltage heating operation. The probe shield, coated with a special material, has withstood several 80 kV discharges, prior to suffering a rather benign failure. An optical coupling system, good to 20 MHz, was placed on order. It will be

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used to electrically isolate the probe, and thereby alleviate the insulation problems.

The Ashbey-Jephcott interferometer has been reinstalled on torus 2 and its redesigned amplifier works well. A great deal of effort has gone into reducing the electromagnetically induced noise that penetrates the sensitive detection system.

A residual gas analyzer (mass spectrograph) system was used to evaluate impurities in the gas immediately after a discharge. Impurity levels were too low to be detected by our system. A more sensitive commercial analysis of the gas samples will be made.

The vacuum ultraviolet spectroscopic system has been tested and it is now being installed on torus 2. A capillary ceramic light source was constructed, and used to calibrate a monochromator. Many lines from this source of moderately ionized O, C, N, and Ar were identified in the 1200-2000 Å range. A new study has begun on the "Doppler-broadening" of lines, such as He II and impurities in the visible spectrum. Expected sources of broadening are the ion thermal and bulk flow motion, and turbulent fields, induced during heating. A polychromator is being assembled for this purpose.

The optical system for CO₂ laser scattering in torus 2 has been designed and bids were solicited for the more expensive components. Bench testing of the CO₂ laser system and its detector system began in late December. Most of the hardware for digitizing the scattered signals has been received.

B. Torus 1:

(J. Marsen, G. Georgiou, S. Paul, G.A. Navratil, R.A. Gross)

Full radial current density profiles were taken in torus 1, using local Rogowski coils, for discharges in both helium and hydrogen. In the case of hydrogen, filamentation occurs 8 μsec. into the discharge, as indicated by streak camera photographs. Current profiles confirm this and show that as the discharge drifts toward the inner wall, a reverse toroidal current develops along the inner wall. This is presumably due to an $I \, dL/dt$ effect. In helium the discharge dynamics are slower and no filamentation is observed. The helium discharge also moves toward the inner wall, but at a slower rate, and later in time, with much less reverse current observed.

Spectroscopic measurements of line/line and line/continuum were made in torus 1 and they indicate that the temperature of the hydrogen plasma

was about 14 eV and the helium was about 6 eV. The mass density of both plasmas were the same. Since the growth rate of the tearing mode is faster at lower temperature, one would predict that if this instability is the cause of the filamentation in torus 1, it should be more readily observed in helium. This is not the case; thus the tearing mode does not appear to be the cause of filamentation in torus 1.

Work continues on the schlieren optical system for torus 1. A pair of short focal length mirrors have been ordered. A general overhaul of cables, preionization system, glass, seals, etc. was completed on torus 1.

C. Engineering:

Our two image convertor cameras, one of which is on loan from LASL, are both very old, each continues to deteriorate, and each requires considerable maintenance and repair.

All our capacitor banks require continual maintenance. Some design modifications have been made on our banks which has helped somewhat. In particular, switch trigger assemblies have been modified to help alleviate mechanical shock problems. Some design improvements in the 100 kV Maxwell bank have been installed.

Several vendors were requested to submit preliminary proposals to extend the test time to 1 msec. in torus 2, by use of three power crowbar systems. No satisfactory proposals have been received. Capacitor bank systems are too expensive. We will explore other energy storage possibilities.

2. BUDGET, SCHEDULE, PERSONNEL

Research progress with torus 2 is continuing satisfactorily, and our budget analysis indicates that we are operating at the rate we had projected. No budget problems are anticipated through to 30 April 1979, the end of the present contract period. We plan to submit our next year's budget request to D.O.E. in early February.

A letter was sent to E.E. Kintner describing the history, background, progress, and commitments made to the Columbia-D.O.E. program. The longer range commitment, previously discussed for the Columbia-D.O.E. research program, was requested.

George Georgiou, a doctoral student, has changed his mind, and he will continue to work on this project. He has, however, changed the direction of his research, and forthwith he will be engaged in Doppler-broadening spectroscopic studies of the torus 2 plasma.

James Marsen, a doctoral student who has been doing research on torus 1, has informed us that he will leave academic studies for an indefinite period, for personal reasons.

3. CAPITAL EQUIPMENT

The following capital equipment items were purchased during the past three months:

2 concave, schlieren quality mirrors & assorted optics	\$1,785
1 50 amp., 6V CAMAC power supply	1,571
3 pyrex, ground & polished plates for torus 2 scattering	900
6 fiber optical line arrays	350
1 mag tape and floppy discs	329
1 model 1301 Type A-1 Crate-controller	785
1 Fibrecom analog optical link	666

4. MISCELLANEOUS: Lectures, publications, trips, etc.

P. Weber and G. Navratil visited ORNL on October 5th and 6th. Dr. Weber presented a seminar describing torus 2 research. Very fruitful discussions were held with the ORNL staff concerning high-beta tokamak research, and in particular, ballooning mode studies.

P. Weber presented a colloquium lecture on torus 2 research to the physics department at Stevens Institute of Technology, Hoboken, New Jersey, on 9 November 1978.

R.A. Gross, T.C. Marshall, G. Navratil, P. Weber, G. Georgiou, and L. Kmetyk attended the American Physical Society annual Plasma Division meeting in Colorado Springs, 31 October through 3 November 1978. Everyone presented papers describing our research.

Dr. Philip Stone

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G. Navratil visited M.I.T. on 1 December and met with R. Slusher (Bell Labs) to discuss and see the CO_2 scattering experiment used on Alcator.

This progress report is submitted by,

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