SUMMARY OF THE SECOND INTERNATIONAL WORKSHOP ON PLASMA FOCUS AND RELATED PHENOMENA, MOSCOW, USSR, SEPTEMBER 21-23, 1981

INTRODUCTION

About 30 foreign and 75 Soviet scientists from 10 countries took part in this Second International Workshop on Dense Plasma Focus (DPF). Twenty-four papers were presented and this final document was developed during a five-hour intensive discussion. Presentations represented more than 40 installations of DPF-like facilities in 15 countries.

STATEMENTS ABOUT DPF PHYSICS

Scaling Laws

In a very large range of energies (from 10 kJ to the maximum operational energy achieved to date of 700 kJ), the physics of the DPF is invariant. Thus, plasma behavior, as well as the energy distribution of particles produced, is observed to be substantially independent of the energy. For neutron optimized regimes, the neutron yield scales as the fourth power of the pinch current. However some divergence from this scaling law occurs at high energies (>600 kJ), apparently due to uncontrolled and poorly understood phenomena occurring during early stages of the discharge.

The use of high voltages has not demonstrated any intrinsic virtue up to now, but this can allow, at high bank energies, a proper electrical and gas-dynamical matching. However, ultra high voltage technology (100 to 1000 kV) has not yet been applied to the DPF.

Neutron Production

Substantial progress has been made in the understanding of neutron production. Converging experimental evidence points to the following model: most neutrons are due to the interaction between relatively low density (10^{17} to 10^{18} cm^{-3}) plasma structures and medium energy (<100-keV) ions confined for a long period of time in a self-sustained magnetic configuration. Further experimental work, such as improved time and space resolution of the neutron source, is required for a final assessment of the model.

High energy deuteron beams (>300 keV) play only a minor role in neutron production. However, there is a direct time correlation between the occurrence of microturbulences and the outset of neutron production.

Beam Production

Present experimental observations rule out the possibility of using a DPF as an ion beam generator to drive pellet implosions due to the relatively low beam efficiency, large beam divergence, large energy spread, and an unfavorable scaling as a function of pinch current. However, for intense electron beam generation, medium energy devices have shown interesting properties, including a high overall efficiency, favorable scaling ($I_{beam} \sim I^3_{pinch}$), and a relatively small divergence of the extracted beam. Experiments at high energy levels are needed to further assess the attractiveness of using DPF in this fashion.

A New Class of Experiments

Several plasma focus devices of the conventional or the hypocycloidal type can be combined to produce long-lived plasmas. The behavior of such systems at high energy levels must be investigated in order to assess their potential for use in various fields of fusion and technology.

STATEMENTS ON PRESENT PROGRAMS

Almost all DPF activities were represented at the workshop. A majority of the DPF groups are located in universities but a few large groups are in fusion laboratories (Kurchatov, Lebedev, Frascati, Poland, etc.). The university groups have generally justified their programs in terms of basic studies. However, groups in fusion laboratories face the problem of defining their goals in the general framework of national fusion programs. The exchange of information between various laboratories appears satisfactory. The coordination of activities has been very successful in some specific cases, but should be further enlarged.

STATEMENTS ON FUTURE PROGRAM

Before constructing multi-megajoule devices, it is necessary to overcome difficulties met at ~700 kJ. For this purpose, several installations at, or slightly above, the megajoule level should be available. Consideration of large devices should be continued. The implementation of a coordinated experimental, theoretical, and computational effort to analyze the difficulties at this level is urgently needed.

It is necessary to develop an extended set of diagnostics, in particular, for the neutron-producing phase. Special attention must be paid to low energy ions (<100 keV) and turbulence in the DPF.

The possible combination of the DPF with other external pulsed sources should be investigated further.

The potential use of the DPF for fusion applications was discussed. Advantages include high Q, favorable scaling, and simplicity. Drawbacks are present troubles at 700 kJ and the lack of a credible reactor conceptual design.

One *proposal* to attack the latter problem was to create a reactor design group in the USSR.

Potential uses of the DPF in other technologies that were considered, such as providing a powerful neutron source (e.g., applications of pulsed sources in physics and technology), would require a major development for high fluences applications. Other applications noted include laser pumping and various medical applications. Possible application of beam generation to inertial confinement fusion appears to be limited to electron beams. Use of the DPF for physics and training is of obvious interest for universities and has the advantage of producing an interesting plasma at low cost.

In conclusion, it appears that energy production should be the major goal of large DPF groups. International collaboration in the DPF community is now in a favorable situation. This may make it possible (and desirable) to propagate the exchange of diagnostics and technology between groups.

THE NEXT WORKSHOP

It was decided to hold the Third Workshop on Plasma Focus in 1983 in Aachen, Federal Republic of Germany, after the Eleventh European Conference on Controlled Fusion and Plasma Physics. H. Herold will serve as the conference executive.

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Editor's Comment: *The Plasma Focus Workshop summarized here was held in conjunction with the Tenth European Conference on Controlled Fusion and Plasma Physics, Moscow, USSR, September 16-19, 1981. This summary was prepared by Professor O. Krokhin, executive for the workshop and Dr. N. Kalachev, scientific secretary. A significant effort in the elaboration of this summary was put forth by the chairman of the closing session, Dr. C. H. Maisonnier. A brief comment on the conference itself appeared earlier in* Nuclear Technology/Fusion, *2, 135 (1982).*

SUMMARY OF THE U.S.-JAPAN WORKSHOP ON DRIFT WAVE TURBULENCE, AUSTIN, TEXAS, JANUARY 11-15, 1982

This workshop was held at the University of Texas and was organized by the Institute for Fusion Studies (IFS) under the agreement between the United States and Japan for the exchange of information in theoretical plasma physics. There were approximately 30 invited scientific participants: 6 from Japan and 24 from the United States. There were six sessions with formal presentations and two sessions for informal discussions of key issues in the problem of drift wave turbulence and anomalous transport.

There were two major goals of the workshop. The first goal was the continuing effort to identify the more plausible anomalous transport mechanisms that take place in high temperature magnetic confinement systems. The second goal was the exchange of recent results between theorists, computer simulationists, and experimenters. Leading scientists representing these three approaches (theory, experiment, and simulation) made presentations reviewing the state-of-the-art in their respective areas. From these presentations, a general sense of understanding emerged as a primary product of the workshop. Some of the problems reported and issues discussed were the following.

The experimenters reported improved resolution in the $\boldsymbol{k},\omega$ space of the measured fluctuations, extension of the fluctuation measurements to new machines, and measurements of magnetic fluctuations in low temperature experiments. Theorists presented alternative explanations for the character of the fluctuation spectra based on renormalized drift wave turbulence theories and the solution of nonlinear dissipative systems exhibiting intrinsic chaotic behavior. In contrast to the weakly correlated turbulence theories, the Japanese emphasized the importance of large-scale correlated structures such as convective cells and solitons. An intermediate point of view of the turbulence was introduced by a theory containing a large number of randomly distributed solitons forming an ideal gas of strongly correlated objects. Simulations were presented by the Japanese of the collisions between drift wave solitons. A theoretical picture containing strong phase space correlations called "clumps" gave an alternative formula for the fluctuation spectrum.

Simulations of drift wave turbulence above (strong gradients) and below (weak gradients) the ion cyclotron frequency and the measured transport of particles and thermal energy were reported by Japan and the United States. A new simulation technique offering the possibility of greatly extended parameter variations and long time runs was also presented.

Discussions on the formulas for anomalous transport centered on the fact that, notwithstanding the importance of empirical scaling laws that synthesize large amounts of experimental data by a particular parameterization, the approach of characterizing the confinement by a formula for the global energy replacement time τ_E is an oversimplification of the issue since transport, atomic physics, and heating mechanisms are interrelated in power balance. The thermodynamic properties of anomalous transport were analyzed.

In a discussion session, the question was debated as to whether it is now timely to assemble the present differentiated areas of knowledge represented at this workshop into an integrated data base giving the present understanding in the field of anomalous transport. Although no consensus was apparent on this issue, there was a sentiment in the direction that the present understanding may well be stronger than generally realized. It is also clear, however, that many new and difficult problems continually emerge, and their solutions will change our understanding of the problem of anomalous transport.

The proceedings of the workshop are available as IFS Report #53.

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REPORT ON THE FOURTH SYMPOSIUM ON THE PHYSICS AND TECHNOLOGY OF COMPACT TOROIDS, LIVERMORE, CALIFORNIA, OCTOBER 27-29, 1981

The Fourth Symposium on the Physics and Technology of Compact Toroids was hosted by Lawrence Livermore National Laboratory (LLNL). Attendees, numbering 80, heard 10 review papers in three morning plenary sessions, and interacted in two afternoon poster sessions where some 45 contributions were presented. There were seven participants from overseas, including six scientists from Japan and one from the Federal Republic of Germany. Immediately following the symposium, a two-day joint U.S.-Japan workshop on compact toroid research was held.