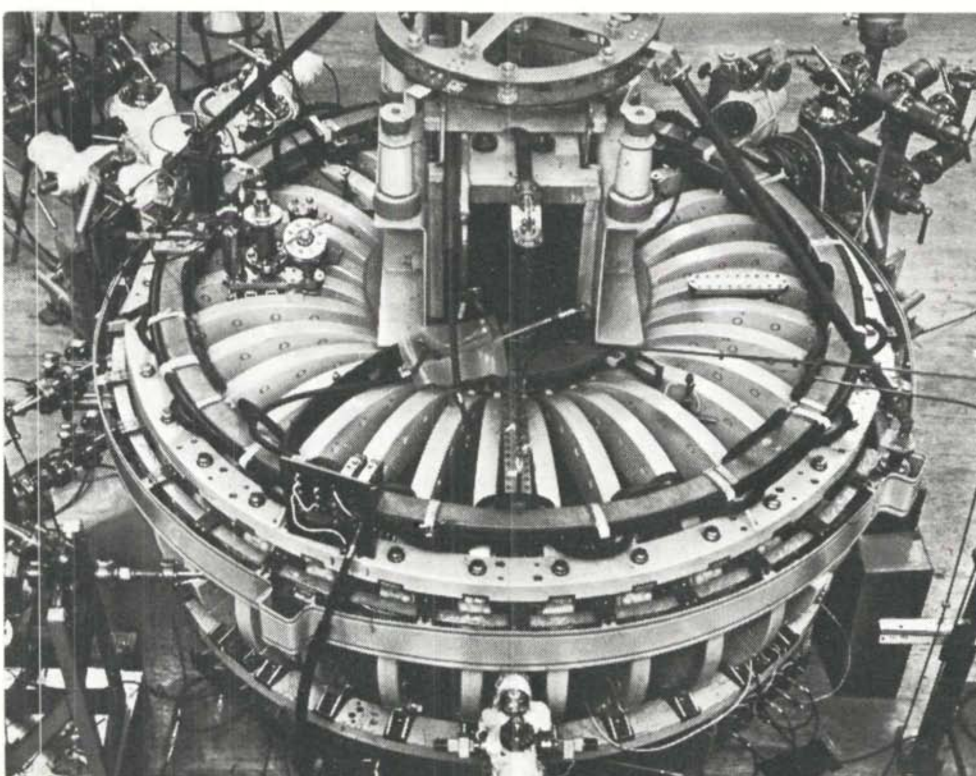
REPORT OF THE 5TH CONFERENCE ON PLASMA PHYSICS AND
CONTROLLED NUCLEAR FUSION RESEARCH, TOKYO, NOVEMBER 1974
The Conference was attended by 445 participants
from 24 countries and four international organizations, as well as 50 observers.

Break-through in Controlled Nuclear Fusion a Possibility

The 5th IAEA Conference on Plasma Physics and Controlled Nuclear Fusion Research demonstrated progress in understanding the physics of nuclear fusion, although no definite major break-throughs were reported at the conference.

MAGNETIC CONFINEMENT SYSTEMS

The general impression from the papers presented is that the steady progress towards the break-even conditions is being made now in both major directions, low-beta (including Tokamaks) and high-beta devices.



In **Tokamaks** the biggest machine which is in operation at present is the French TFR. The very preliminary results which were published at the conference show that the ion temperature grew as expected according to the scaling law, however, electron temperature and confinement time did not scale accordingly. Future work on TFR will be followed closely, as well as results of experiments on even bigger devices, T-10 (USSR) and PLT (USA), at present under construction.

Although all the presently running **Stellarators** still suffer from their small plasma dimensions, interesting new results were obtained on the comparison of diffusion rates in omically heated Stellarators (Wendelstein IIb) and Tokamaks.

In the near future several somewhat larger machines will be available.

In high-beta devices several successful experiments have been reported at Isar T1 and Scyllac – both high-beta Stellarators, the existence of toroidal equilibria was demonstrated and attempts are being made to improve the performance by introducing the feed back stabilization. Shock heating of plasma was demonstrated in a number of experiments to be a fast and effective way of heating primarily ions and simultaneously providing a separation of plasma from the wall, which might result in a reduction of impurities.

In another group of high-beta devices, screw pinches, several interesting experiments have been reported, in particular for the pinches of elongated cross sections or belt pinches which now seems to be a promising development, allowing them, in theory, to operate with much higher currents.

The Conference also showed that additional **heating** would probably be required at least for the first break-even fusion experiments. Most attention is being paid to neutral injection, on which interesting results were reported by ORMAK and ATC groups. Methods of RF heating of plasmas were also discussed.

The problem of **impurities** was not completely clarified at the conference. Some groups stated that within a factor of two there is no indication of accumulation of impurities at the plasma centre. This is in contradiction to earlier observations of Kurchatov Tokamaks. Several possible ways of reducing the impurity level were extensively discussed, among them the "cold plasma blanket". There are some experimental evidences (JFT-2 and Heliotron-D devices) that the separation of a plasma and a wall by means of a cold gas blanket might improve the plasma behaviour.

INERTIALLY CONFINED SYSTEMS

In the field of laser-produced plasmas experimental demonstrations of compression were performed in the USSR at the Lebedev Institute, and in the USA at KMSF and Los Alamos. Up to 100 times compression was observed for DT-filled glass shells (KMSF) and CD_2 pellets. A yield of 10^5-10^7 neutrons, believed to be of thermonuclear origin, was also observed in those experiments.

Newer and bigger lasers are under construction now in USSR, USA, FRG, and Japan, and one could expect results closely approaching the break-even conditions in 1975/76 (that is, when the amount of energy spent for the reaction is equal to the net gain of energy). Experiments on plamas produced by **electron beam irradiation** of a spherical target was reported by groups of the Sandia Laboratory and the Kurchatov Institute. Densities (10^{21} cm^3) and temperatures of plasma (0.5-1 KeV) obtained in the experiments are close to the parameters of laser-produced plasmas. It now looks as if these two branches of intertially confined systems have reasonable prospects for the future.

Another interesting concept for the future which was also explored further, was the use of an **imploding liner** to achieve high energy density fusion plasmas. The idea, however, needs experimental verification.

The 5th Conference showed noticeable changes in both the role and direction of **theoretical studies**. If beforehand plasma theory had its own line of development, it now has more an applied purpose to explain and understand experimental results. Plasma stability in complex toroidal configurations was one of the major concerns of the theoreticians in Tokyo, including such problems as plasma confinement by means of feed back stabilization, plasma in systems with divertors, optimization of toroidal geometry and the shape of the cross section of a plasma column. Various aspects of the influence of impurities on plasma were also discussed, as well as possible ways of decreasing their accumulation in plasma. Various instabilities have been treated in a large number of papers as at previous conferences, but at this conference, however, there were no reports on funding substantially new types of instabilities. Instead, known types have been further studied, for example the ion and electron trapped instabilities, MHD instabilities of plasma with the noncircular cross section of the column.

The theory of interaction of laser and relativistic electron beam interaction with targets has recently been intensively studied in the US and USSR. The results of detailed numerical simulation experiments of multi-layer targets was presented for the first time at the Tokyo conference. It was shown that with such targets substantial gain in efficiency can be obtained, and restrictions to the shape of the laser pulse could be reduced.

About 10% of the papers were devoted to **reactor systems**. This topic was also discussed at a special evening session where the results of the Culham Workshop on Reactor Problems (Culham, UK, February 1974) were presented.

A new concept of the "wet-wood burning" reactor has been developed by several research groups from the US. This is a two component system with relatively cold plasma and injection of a fast neutral beam. It can be used to study the plasma at near-reactor conditions and as an intense neutron source for material research. Such mirror and theta pinch based facilities, FERF (Fusion Engineering Research Facility), were presented by the Livermore and Argonne group respectively.

In the same line are conceptual designs of hybrid fission-fusion reactors where additional energy is gained from blankets containing fissionable materials.

It seems possible that along the above directions one can expect the first break-through in controlled nuclear fusion.