intensity may reach values higher than the critical values of the superconducting coils, because the magnetic field configuration of the Spheromak is typically a force-free one.

Linus is a device particularly suited to reach extremely high power densities. By means of Linus, an inertial confinement of the plasma is obtained by imploding a mechanically driven liquid liner (see A. E. Robson's lecture). Among the imploding liner systems (see lectures of J. C. Linhart), the Linus concept provides an example of slow implosion that confines the plasma for a time, which is long enough for a good burn, but too short for a significant loss of energy by diffusion.[d] These happy circumstances deteriorate if Linus is scaled down to a smaller size for testing the concept: Linus cannot be a research toy, but only a reactor, and this fact probably embarrasses the decision makers.

The plasma is produced, together with the confining field, by two rotating electron beams launched in opposite directions in the gaseous fuel. This method, *per se* interesting, is being investigated at the Naval Research Laboratory. In general, electron rings appear to be important ingredients in many devices (see lecture of R. N. Sudan).

The imploding liner is a thick cylindrical rotating shell of lithium, with a multipurpose function (besides tamping): near-megagauss magnet, renewable first wall, neutron shield, tritium breeder and coolant. Consequently the engineered volume is relatively compact and not costly. This is probably too good to be true!

According to the Linus scheme presented during the course, the fusion power density in the plasma results in being of the order of 1 GW/m^3 during burn. The tremendous wall loading of the order of 1 GW/m^2 (time average: 20 MW/m^2) is withstood by the liquid lithium wall; the fusion alpha particles push back the liquid liner, which is heated by neutrons and transfused in order to extract and use the thermal energy and tritium produced.

In regard to advanced fuels without neutrons and/or not needing to be bred, G. H. Miley has classified them according to proton- and deuterium-based reactions, and has presented some possible interesting strategies for both classes of fuel. In light of the considerations presented, present-day fusion research could be considered a necessary exercise toward the use of advanced fuels, which should satisfy the most exigent ecologist. Recent studies on the various reactivities (F. F. Chen has also reported unpublished results at the University of California at Los Angeles) have shown the enhancement of $\langle \sigma v \rangle$ due to the beneficial distortion on the Maxwellian tail induced by the fast reaction products before completion of their slowing down, and have revived the hope for p-^{11}B ideal ignition.

A plasma ignited by proton-based reactions has losses dominated by radiation and consequently the considerations previously made with regard to the conduction regime are not applicable in this case.

The space distribution of the magnetic field produced by multipoles has good confining properties and keeps low the level of cyclotron radiation.

The frightening problem of maintaining at low temperature the levitated superconducting hoops strongly irradiated by the plasma has been faced recently. F. F. Chen has reported encouraging results of shielding design studies of a floating ring for a D-^{3}He tandem mirror: the superconducting state is preserved for about five days and, in a neutronless case, for about one month.

The other worrying problem of cooling a wall under heavy x-ray bombardment has stimulated and produced interesting ideas such as that of depositing the radiation in a high-Z gas flowing behind a thin first wall.

Among the deuterium-based fuels, particular attention has been given to the D-^{3}He reaction, considering conceptual reactors based either on multipoles or on tokamak magnetic configurations. For the latter case, B. Coppi has presented a proposal of a high field tokamak with a strongly diamagnetic plasma: more precisely, a low-beta D-T plasma brings to ignition the D-^{3}He fuel and evolves towards a second stability region at high beta ($\sim$15%).

At a vivacious round-table discussion, chaired by F. F. Chen, the main issues that emerged during the first week of the course were discussed.

The final three days were spent reviewing conventional or almost conventional fusion machines: stellarators, mirrors, reversed field pinches, Elmo Bumpy Torus, compact tori.

The focus was not only on the parameters achieved, but more on the meaning of the most recent physics studies and what they implied about the future for these approaches.

Bruno Brunelli

Comitato Nazionale per l'Energia Nucleare
Associazione Euratom-CNEN
Centro di Frascati
Via Enrico Fermi - Casella Postale N. 65
00044 Frascati, Roma, Italy

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Editor's Comment: *This report, prepared by Prof. Brunelli, is taken, with permission by Plenum Publishing Co., Ltd., from the Foreword to the forthcoming proceedings of the course on Unconventional Approaches to Fusion held at the Center for Scientific Culture. Prof. Brunelli served as organizer and director of the course. Due to its interest for readers of* Nuclear Technology/Fusion, *this summary of the technical discussions at this international course is presented here. The full proceedings should be available through Plenum early in 1982.*

REPORT FROM THE TENTH EUROPEAN CONFERENCE ON CONTROLLED FUSION AND PLASMA PHYSICS, MOSCOW, USSR, SEPTEMBER 16-19, 1981

This international conference contained a variety of review and contributed papers on topics ranging from basic plasma physics phenomena to recent results in both magnetic and inertial confinement experiments and physics. Details of the papers can be obtained in the two-volume proceedings (Vol. I: 204 contributed papers, and Vol. II: invited plus 25 post-deadline papers) published through I. R. Gekker, Scientific Secretary, Lebedev Physical Institute, Academy of Sciences, Leninskiy Prospekt 53, Moscow, USSR. While a number of areas covered in the meeting are of potential interest to readers of *Nuclear Technology/Fusion*, space restrictions force us to concentrate on the highlights of the session on "Reactor Problems."

[d]Hence the considerations made for a diffusive stationary plasma are not applicable here.

V. M. Trukhin of Kurchatov Institute provided original drawings for the 11 topical headings of the meeting (used on posters and in the proceedings), and his contribution to the Reactors session appears as Fig. 1. Four papers were concerned with alpha particle dynamics. U. Carretta et al. (CNR-Euratom Association, Milan, Italy) reported studies of alpha dynamics in both low- and high-density ignition devices based on compact torus concepts. They found favorable results for higher densities ($n_e \approx 2 \times 10^{15}$ cm^{-3}) where a quasi-steady-state distribution function occurs in ~14 ms, leading to ignition. D. Anderson et al., of Chalmers University, Sweden, studied alpha-particle losses due to ripple fields in tokamaks and found that pitch angle scattering into the loss region in velocity space can be significant. For a typical case they report 40 to 60% particle and 15 to 30% energy loss fractions. V. Ya. Goloborodko et al., of the Institute for Nuclear Research, Kiev, USSR, have developed a new theory for alpha-particle bootstrap currents that shows that this may possibly serve as a "seed" current for steady-state operation of a tokamak provided that $Z_{eff} > 2$ can be tolerated. The possibility of increasing ion heating by coupling of high-energy alpha particles to shear Alfvén waves was discussed by G. Miley and W. Sutton (University of Illinois, Urbana, Illinois), who reported a repetitive "hiccup" type instability under some circumstances. In a related paper, F. Pegoraro (Scuola Normale Superiore, Pisa, Italy) and B. Coppi (Massachusetts Institute of Technology, Cambridge, Massachusetts) question the validity of "conventional" shear-Alfvén wave analysis based on normal mode techniques. With the exception of a restricted "opalescent" oscillation region, their analysis, based on statistical wave packet techniques, suggests the shear Alfvén effect may be small.

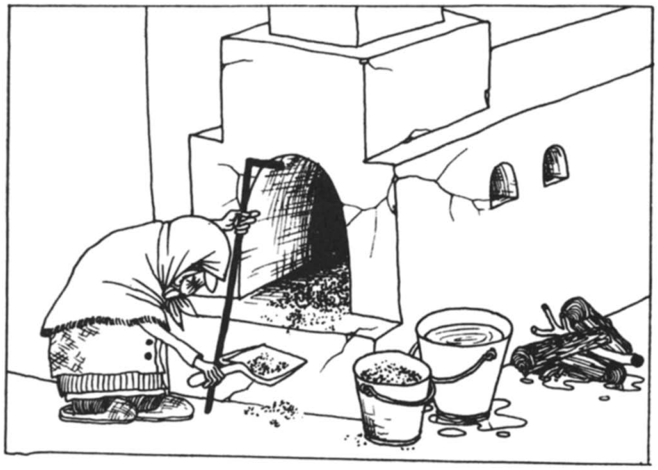

Fig. 1. Reactor problems.

In a series of separate presentations, Yu L. Igitkhanov (I. V. Kurchatov Institute, Moscow, USSR), T. E. Volkov and V. D. Kirillov (I. V. Kurchatov Institute), A. V. Nedospasov et al. (High Temperature Institute, Moscow, USSR), A. S. Kukushkin et al. (I. V. Kurchatov Institute), and A. V. Bazaeva et al. (Physical Technical Institute, Kharkov, USSR) considered a range of problems related to the use of magnetic divertors and scrape-off layer physics. The emphasis on this area was apparently motivated, at least in part, by a growing feeling that a magnetic divertor would be used for INTOR (cf., the INTOR overview presentation by G. Grieger, Max-Planck Institute, Garching, Federal Republic of Germany). While the INTOR team now favors a single null poloidal divertor, A. V. Bazaeva et al. advocate a modified bundle divertor concept using multipole windings, called the local hybrid divertor. Other papers dealing with INTOR described the modeling of startup scenarios (V. A. Abramov et al., Kurchatov Institute) and of the anticipated poloidal field (P. N. Vabishchevich et al., Keldysh Institute of Applied Math, Moscow, USSR).

Other papers in the session were related to burn dynamics, namely, refueling via pellet injection by N. N. Vasil'ev (High Temperature Institute) and combined impurity-compression/expansion techniques for feedback control by A. Sestero (Centro di Frascati, Rome, Italy) and to the economic assessment of hybrid reactors (Tokamak Hybrids by A. V. Komin et al., of the D. V. Efremov Scientific Institute, Moscow, USSR, and A. S. Kukushkin et al., of the High Temperature Institute; Laser Fusion Hybrid by Yu. K. Kalmikov et al., of Efremov and V. B. Rozanov, of Lebedev). Both hybrid papers concluded that if good plasma performance is achieved, hybrids are "close to competitive." However, in informal discussions the authors advocated continued stress on the parallel development of pure fusion and hybrids although they felt that the hybrid is likely to be the first application for fusion in the USSR. In an interesting, but quite speculative invited paper, L. Ponomarev (Joint Institute for Nuclear Studies, USSR) described the possibility that muon catalyzed deuterium-tritium fusion might drive a hybrid with a positive energy gain.

Following the conference three workshops were planned: one on plasma focus and microliners and separate International Atomic Energy Agency (IAEA) workshops on open systems and on stellarators. Reports from the latter two are to appear in the IAEA journal *Nuclear Fusion* while a summary of the plasma focus workshop is scheduled for a future issue of *Nuclear Technology/Fusion*.

G. H. Miley

University of Illinois
Fusion Studies Laboratory
Nuclear Engineering Program
Urbana, Illinois 61801

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