MEETINGS AND CONFERENCES

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on October 30 and 31, 1974 at the Conference Hall of the P. M. Lebedev Physics Institute. The following papers were delivered:

1. G. B. Abdullaev, Thin-Film Switching Devices with Controlable Electric Memory Based on Compound Crystalline Semiconductors.

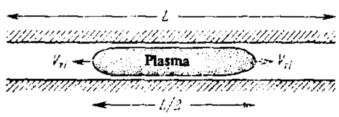
2. D. D. Ryutov, Controlled Thermonuclear Fusion in a Dense Quasistationary Plasma.

3. P. V. Sumaruk and Ya. I. Fel'dshteĭn, Interplanetary Magnetic Fields and Geomagnetic Variations in the Subpolar Region.

4. R. A. Syunyaev, "Black Holes" and Neutron Stars in Binary Stellar Systems.

We publish below brief contents of two of the papers.

D. D. Ryutov. Controlled Thermonuclear Fusion in a Dense Quasistationary Plasma. For the past several years, the Novosibirsk Institute of Nuclear Physics has been engaged in research with the object of determining the possibility of designing a thermonuclear reactor based on direct dense-plasma systems[1]. Longitudinal thermal insulation of the plasma can be ensured by setting up the plasma in the form of a bunch separated by vacuum gaps from both ends of the device (see figure);



a homogeneous longitudinal magnetic field can be used for transverse confinement. This is a very simple system, and there is no doubt that it will work. However, it has two serious shortcomings. Firstly, because the longitudinal expansion time of the plasma L/V_{Ti} (L is the length of the device and V_{Ti} is the thermal velocity of the ions) must exceed the Lawson time, the device must be very long: $L\ (\text{cm}) \gtrsim 2 \times 10^{22}/n\ (\text{cm}^{-3})$ (n is the density of the plasma), i.e., even at $n = 3 \times 10^{17}\ \text{cm}^{-3}$ the device would have to be about 1 kilometer long. Secondly, magnetic confinement of a dense plasma requires a strong magnetic field ($H \gtrsim 3 \times 10^5$ G), creation of which in a large volume would encounter serious difficulties.

The Novosibirsk Institute has found one possible way of greatly reducing the length of the device[2]. It consists in abandoning the homogeneous magnetic field in favor of a so-called "multimirror" field (the device becomes a sequence of "probkotron" mirror machines connected end-to-end). A single probkotron must be shorter than the free path of the charged particles, which, in turn, is short in a dense plasma as compared to the length of the device. Transition to the multimirror magnetic field has as a consequence that the inertial excursion of the plasma becomes a slow diffusive expansion, so that the length of the unit can be reduced substantially. A quantitative theory describing the flow of a plasma in a multimirror magnetic field was constructed in[3] and model experiments were performed on a low-temperature alkali plasma in[4]; they fully confirmed the theory.

As for the transverse thermal insulation, a plasma of density $n \sim 3 \times 10^{17}\ \text{cm}^{-3}$ offers the possibility of using "nonmagnetic confinement" (see, for example,[1,5]), in which transverse equilibrium is ensured by direct contact of the plasma with the walls of the working volume and the magnetic field serves only to suppress transverse heat conduction. This makes it possible to change to relatively weak magnetic fields $H \sim 10^5$ G and eliminates the second of the difficulties mentioned above. Numerical calculations made thus far have yielded plasma lifetimes for nonmagnetic confinement under a broad range of experimental conditions.

A hypothetical thermonuclear reactor based on the above principles might have the following parameters: number of probkotrons 40, mirror ratio 3, total length of device 30 m, average plasma radius 5 cm, average magnetic field intensity 100 kG, plasma density 3×10^{17} cm^{-3}, plasma temperature 10 keV, total plasma enthalpy 100 MJ. Here the average radius of the plasma is estimated at $R = 5$ cm on the assumption that the transverse thermal conductivity equal 1/30 of the Bohm coefficient. If the transverse losses were classical, $\bar{R}$ would be reduced to 1.7 cm and the total plasma enthalpy to 10^7 J.

Powerful relativistic electron beams (REB) could be used to heat the plasma in installations of this type. The existing theory[6] and experiments that have been performed[7] indicate high efficiency for the interaction of the REB with the plasma. REB generators with total pulse energies up to 1 MJ already exist[8]. A recently proposed[9] and experimentally tested[10] method of increasing the electric strength of liquid dielectrics (used in energy accumulators for REB generators) supports the hope that more powerful sources may appear.

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