$a_{\pi\pi} = 8$ (GeV/c)$^{-2}$, respectively. As seen from the figure, a more accurate allowance for the energy dependence of N^{eff}, together with allowance for the violation of the VDM (curve 3), results in the best agreement between theory and experiment. In our opinion, this agreement confirms the correctness of the fundamental principles on which the theory of incoherent processes, developed in [6], is based. This makes it possible to apply this theory to the analysis of incoherent production of unstable particles and to determine the characteristics of their interaction with nucleons.

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STABILITY OF A TOKAMAK WITH A NON-ROUND PLASMA-LOOP CROSS SECTION

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In connection with the interest aroused by Tokamaks with quasi-elliptic cross sections [1], it is timely to discuss some questions involved in the stability of such systems, and in particular the resultant limitation on the plasma pressure.

The destabilizing factors responsible for the hydromagnetic instability of the plasma are, generally speaking, the pressure gradient and the longitudinal current in the plasma torus, and the stability conditions impose limitations on both these quantities. The conditions of local stability for configurations in which the plasma pressure falls off away from the magnetic axis turn out to be most critical in the vicinity of the magnetic axis. For a system of the Tokamak type, Mercier's necessary stability criterion [2, 3] and the sufficient criterion [4, 5] (derived for arbitrary toroidal configurations) reduce in this case, respectively, to the conditions

$$\frac{A-(1+\epsilon/2)(1+\epsilon)x^2}{R^2} - \frac{2\epsilon^2\beta}{(1+\epsilon+\sqrt{1-\epsilon^2})^3 a^2 x^2} > 0, \tag{1}$$

$$\frac{A-(1+\epsilon/2)(1+\epsilon)x^2}{R^2} - \frac{\beta}{(1+\epsilon)^2 a^2 x^2} > 0. \tag{2}$$

The first terms, which are the same in both criteria, describe the magnetic well ($\sim -V''(\phi)$, where ϕ is the longitudinal magnetic flux)

$$x = \frac{jR}{2B}, \quad A = 1 + \frac{3\epsilon}{4}(1+\Gamma) \tag{3}$$

(x is a quantity reciprocal to the "local" stability margin q), $\vec{B}$ and $\vec{j}$ = curl $\vec{B}$ are the magnetic field and the current density, $\varepsilon = (\ell_z^2 - \ell_r^2)/(\ell_z^2 + \ell_r^2)$ is the ellipticity of the normal cross sections of the magnetic surfaces in the vicinity of the magnetic axis $r = R$. Γ is the parameter of the asymmetry of the cross sections, $\beta = 2p_0/B^2$, $p = p_0(1 - V/V_\Sigma)$, $V_\Sigma = 2\pi^2 abR$, $a = (\ell_r)_\Sigma$, and $b = (\ell_z)_\Sigma$.

According to the criteria (1) and (2), the stability is determined by the magnetic well that is produced automatically when the plasma loop is rolled up into a torus, and depends on the ellipticity ε and on the asymmetry Γ of the cross sections of the magnetic surfaces. In the case of symmetric elliptic sections $\Gamma = 0$. At $\varepsilon > 0$ we get $\Gamma > 0$ if the profile of the cross section becomes sharper on the outside (away from the torus axis z). When $\varepsilon < 0$ we have $\Gamma < 0$ for profiles sharpened in the opposite direction.

In the case of round cross sections of the magnetic surfaces near the axis ($\varepsilon = 0$) we get $A = 1$ and the influence of the asymmetry of the cross sections vanishes. In this case, according to the necessary criterion (1), the limitation on the plasma pressure is also eliminated. However, the sufficient criterion (2) (which coincides at $\varepsilon = 0$ with the criterion of Ware and Haas [6]) leads to a limitation on the pressure also in the case of round sections.

The necessary and sufficient stability criteria (1) and (2) differ from each other in the values of the destabilizing terms, which are proportional to β, and the ratio of these terms depends only on the ellipticity ε. At small ε this ratio ((2)/(1)) tends to $4/\varepsilon^2$; when $\varepsilon \to -1$ it is also large, $\sim\sqrt{2/(1+\varepsilon)}$, but when $\varepsilon \to 1$ the necessary and sufficient criteria become equal.

In the general case, the criteria (1) and (2) are equivalent to the requirement that the quadratic trinomial in the variables x^2 be positive; for different values of β, the regions of stability with respect to the longitudinal current are bounded by the corresponding curves shown in the figure.

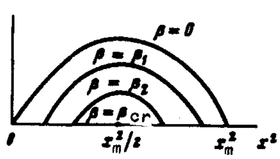
The maximum region of stability with respect to the current corresponds to $\beta = 0$. At $\beta = \beta_{cr}$ this region contracts to a point in the vicinity of $x^2 = x_m^2/2$ and vanishes.

For a Tokamak with round magnetic-surface sections, the necessary criterion (1) reduces to a limitation on the current $x^2 < 1$, and does not contain any limitations on the pressure, whereas the sufficient criterion (2) leads to the condition

$$-\sqrt{\frac{1}{4} - \frac{\beta R^2}{a^2}} < x^2 - \frac{1}{2} < \sqrt{\frac{1}{4} - \frac{\beta R^2}{a^2}}. \qquad (4)$$

From (4), as $\beta \to 0$, it follows that $x^2 < 1$, and the value of β is bounded by the relation $\beta \le \beta_c r = a^2/4R^2$. The experimental data obtained with Tokamaks apparently offer evidence that the real stability region is better described by the sufficient criterion (2) than by the necessary one (1).

According to the sufficient criterion (2), elongation of the magnetic-surface sections along the normal to the magnetic axis ($\varepsilon < 0$) leads to larger limitations on the pressure, and therefore the opposite case, when the sections are elongated along the torus axis z, is preferred.



In the limit when the ratio b/a is large, the necessary and sufficient criteria (1) and (2) coincide, and the stability criterion obtained in this manner reduces to the condition

$$-\sqrt{\left(\frac{A}{6}\right)^2-\frac{\beta R^2}{12a^2}} < x^2-\frac{A}{6} < \sqrt{\left(\frac{A}{6}\right)^2-\frac{\beta R^2}{12a^2}}, \qquad (5)$$

where $A = (7 + 3\Gamma)/4$. From (5), as $\beta \to 0$, it follows that $x^2 < A/3$, whereas for β we get the limitation $\beta \leq \beta_{cr} = (A^2/3)(a^2/R^2)$. For the configuration considered in [1] we have $\Gamma = \sqrt{2R}/z_1 \simeq 1$ and $A \simeq 5/2$.

The limitations that follow from the required existence of equilibrium, and also the required stability against helical coiling of the plasma loop, are less stringent than those considered above, and are therefore not discussed here.

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MEASUREMENT OF THE ENERGY LIFETIME OF THE IONS IN THE TO-1 TOKAMAK

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As is well known, an important characteristic of thermal insulation of a plasma in a closed magnetic trap of the Tokamak type is the time of conservation of the thermal energy in the ionic component of the plasma. Until recently, this quantity was usually determined from the energy-balance equation, based on the assumption that the energy is transferred from the electrons by the Coulomb mechanism in Joule heating of the plasma [1, 2]. Experiments with the TO-1 setup [3] yielded the dependence of the energy content of the plasma on the time in the case of magnetosonic heating of the ions, which permitted a second independent estimate of τ_{Ei}. It is of interest to compare the ion energy lifetime determined from this dependence with the value calculated from the energy-balance equation.

The equation of the energy balance of the ions, referred to the volume of the plasma filament, can be expressed as follows:

$$\frac{3}{2}\frac{d}{dt}\int nkT_i\,dV = P_{ei} + \tilde{P} - \frac{3}{2}\frac{\int nkT_i\,dV}{\tau_{Ei}}. \qquad (1)$$

The quantity τ_{Ei} in (1) is a characteristic of the thermal insulation of the ionic component of the plasma filament as a whole. P is the HF power absorbed by the ions as a result of the magnetosonic heating. P_{ei} is the energy transferred from the electrons to the ions per unit time. If the energy transferred from the electron to the ion in each interaction act differs by a factor γ from the energy transferred in a Coulomb collision, then we have on the basis of [2]