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KADOMTSEV'S TOKAMAKS SIMILARITY SCALING FOR A HYBRID FUSION REACTOR *)

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To develop a hybrid thermonuclear reactor (FNS) project, it is necessary to use reasonable scalings based on the analysis of numerous experiments on tokamaks with various parameters. The most general fundamental approach to considering a tokamak as a complex system was proposed in the classical works of B. B. Kadomtsev [1,2], who considered the similarity of tokamaks based on the analysis of dimensions (an analogue of the symmetry analysis) and the properties of self-organization in a complex system with a huge number of degrees of freedom of plasma in a tokamak. When analyzing the dimensionless parameters in [1], Kadomtsev considered an idealized approach of pure (without impurities) plasma in a tokamak, with eleven basic quantities: (a, R, Bz, Bp, c, e, m, M, Te, Ti, n). Based on such an analysis for the parameters of the central tokamak plasma a scaling of the similarity of tokamaks, SK, was proposed, characterizing the dependence on the aspect ratio A, major radius R, toroidal magnetic field Bz on the axis, atomic mass of ions M of a family of plasma systems equivalent in terms of energy confinement, see [3,4]:

$$S_K = RB^{4/5}A^{-3/2}M^{-3/5} \quad . \qquad (1)$$

As discussions continue on the advantages of tokamaks with different A at the same magnetic field and plasma current, the question arises about the choice of parameters of a hybrid fusion reactor. In [4,5], a modified scaling was proposed taking into account the characteristics of the thermonuclear product – power gain Q for tokamak reactors. At the same time, such a modification did not take into account the important processes that effect on the stability, including steady state operation, of such a complex system as a tokamak: the plasma-wall interaction and strong plasma turbulence affecting the system, identified in recent experimental studies [6]. For further development of the tokamak similarity approach, it is necessary to take into account the parameters of the plasma-wall interaction and plasma turbulence.

In this paper, it is proposed to consider a modified Kadomtsev SK-P scaling for a tokamak reactor:

$$S_{K\text{-}P} = RB^{x}A^{y}Q^{z} \quad , \qquad (2)$$

where the indices *x, y, z* will be functions of the parameters of the plasma-wall interaction and of the parameters of strong plasma turbulence, such as scalings of the spectra of turbulence and anomal plasma transport (superdiffusion), scaling erosion of plasma-facing materials affecting the entry of impurities into the discharge, characteristics of arc processes on the wall, the currents from the plasma to surface and ambipolar diffusion. In particular, it is necessary to consider the effects of violation of quasi-neutrality in the near-surface layer at the discharge boundary, i.e. in the problem of tokamaks similarity , the consideration of the number of N_D particles in a Debye sphere should be preserved.

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