PLASMA equilibrium AT the high-beta LIMIT in an axisymmetric open trap

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Diamagnetic confinement is a new concept designed to increase plasma parameters in axisymmetric open magnetic traps. The analytical theory of the equilibrium of high-pressure plasma in the diamagnetic confinement mode in the paraxial approximation is described in [1]. In this equilibrium the magnetic field within the plasma in the central region of the trap (near the minimum of the vacuum field) is reduced almost to zero, and the diamagnetic "bubble" is formed. The regime can also be considered as the limiting case of a specific FRC, which has finite radius but the reversed field tending to zero. Because of the nonparaxiality of the equilibrium, the applicability of the published analytical theory is limited. At the same time, the standard numerical iterative solution of the Grad-Shafranov equation with a given plasma pressure distribution is not applicable. First, the desired equilibrium has a pressure limit whose magnitude and profile are unknown in advance. Second, in the vicinity of the pressure limit, the standard iterative method (that has no respect for the Ohm’s law or field topology) causes convergence of iterations to FRC configurations rather than the desired linear trap.

The present paper is devoted to numerical study of the high-beta plasma equilibria in axisymmetric open traps in the presence of transport effects. Modeling of the plasma equilibrium is carried out by solving the equivalent of the Grad-Shafranov equation [2, 3]. The transport effects are described via flux-surface-averaged diffusion equation in a magnetic field obtained within the MHD framework. The resulting system of equilibrium and transport equations describes both the equilibrium and self-consistent formation of the plasma pressure profile. The system is significantly nonlinear, and its solution is not necessarily unique. A new iteration scheme based on the sequential application of small corrections to paraxial equilibrium is used to select solutions with the desired topology of the field lines (i.e. without FRC) and to accelerate the algorithm convergence in the case of a quasi-homogeneous external field.

References

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