REgime of diamagnetic confinement in a linear axially symmetric trap

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Regime of diamagnetic confinement in a linear trap is the limiting case of equilibrium, when the diamagnetic currents of plasma cause reduction of the internal magnetic field within significant plasma volume to near zero, i.e. it is the β>>1 limit via the local field in this volume. The special role of such equilibria for confinement follows from the fact that while the local field is reduced, the corresponding mirror ratio grows, in the limit – up to infinity, so that the axial confinement time will increase accordingly. However, it is also obvious that without special measures such equilibrium will be unstable: the ballooning instability as well as kinetic instabilities related to anisotropy of the distribution function will be present. It is also true that the plasma pressure at the edge cannot be large, so that the confinement will be enhanced for only a part of the plasma volume. Thus the problem is in two parts: is it possible to create a stable configuration with a diamagnetic “bubble”, and how large will be the enhancement of the total energy confinement time. Based on rough analytic models it can be shown [1] that in a mirror with a long stretch of quasi-uniform field in the middle such equilibrium can be reached and maintained. The gain in quality of confinement can be enormous: if the axial losses are gas-dynamic, while the transverse diffusion of the magnetic field is described by classical conductivity then, unlike in classical traps, one can reach plasma ignition in a 30-m long system.

Considering the importance of the issue, the published in [1] theoretical description of the concept of the diamagnetic confinement is insufficient. This work is devoted to further development of the theoretical model. In particular, it is taken into account that the gas-dynamic model of axial losses is not applicable to the edge layer of the equilibrium at fusion conditions, where the confinement regime will be kinetic. As a result of kinetic confinement the predicted gradient length in the edge layer will be significantly larger, while the expected confinement time will increase even further. Possibility of development of drift modes and their effect on confinement are considered.

References

1. Beklemishev A.D. Diamagnetic “bubble” equilibria in linear traps //Physics of Plasmas. – 2016. – V. 23. – №. 8. – P. 082506.