Confinement Studies for Future Devices Beyond ITER

A. Fujisawa

National Institute for Fusion Science,322-6 Oroshi-cho, Toki 509-5292, Japan

fujisawa@nifs.ac.jp

The research aiming at realizing a sun on the earth has been carried out for more than 50 years. The efforts have made the physics of magnetically confinement promoted along with the development of fusion technologies. Finally, a device, ITER, is being constructed to obtain the plasma in a burning state. The burning plasma may show properties that could be completely different from those of the present plasma sustained by external energy supplies. However, tokamak is on the closest position to Demo since only the burning property of the tokamak plasma will be known in the near future and the tokamak researches over 40 years have provided a huge amount of experimental data bases.

The studies of other magnetic configurations, however, should still continue to be carried out to demonstrate their own **advantages** or **individuality** by supplementing the absent characteristics of standard tokamaks. Stellarators, including a wide variety of concepts, are characterized by no internal current giving superiority in steady state operation. Stellarators can easily exceed three times higher density of the Greenwald limit. Recent studies in stellarators found many interesting operational regimes, such as super dense core (SDC) in LHD [1] and high density H (HDH) mode in W7-AS [2]. Besides, the spherical tokamaks are characterized with extremely low aspect ratio giving a large plasma volume relatively to the device length size. The spherical tokamaks demonstrate the possibility of extremely high β operation exceeding 40% together with high plasma confinement due to the large capacity of plasma current [3].

On the other hand, the recent development of theories and plasma diagnostics also has shown a new paradigm [4,5], **common** for magnetically confined plasmas, to determine the turbulence saturation and the result transport level. In the paradigm, the turbulence should be recognized as the system of zonal flows and drift waves. The energy balance between them, which determines the plasma confinement, should be deeply associated with the flow-damping rate, such as collisionality and parallel viscosity. The parallel viscosity is associated with the non-axisymmetric characteristics of magnetic field configuration. Hence, the magnetic field configuration with better axisymmetry should give a better confinement. Therefore, the new paradigm could provide an optimization principle for the magnetic field configuration in the light of turbulence transport.

Finally, the comparative studies of various concepts should be necessary to optimize magnetic field configuration in terms of confinement (or turbulent transport), energetic particle behaviour etc., and to realize an advantageous device incorporated with different concepts in terms of the economic and steady state operation. This paper will discuss several physical and experimental topics associated with obtaining a better solution of a magnetically confined fusion device in future.

References

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