# §10. Effect of Elongation on Transport in ECH Plasma

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Extensive efforts to document the characteristics of an energy confinement time have been made under the international collaboration for inter-machine comparison. A recent important remark from this collaboration is that anomalous transport is suppressed in the configuration where the neoclassical transport is suppressed [1] although the mechanism has not been clarified. A large flexibility of the magnetic configuration of LHD has been making a unique contribution to investigate the effect of configuration property on confinement and transport. In particular, the energy confinement indicates a clear dependence of the magnetic axis position. High performance can be obtained at $R_{ax}$~3.6m in the vicinity of the configuration with the minimum effective helical ripple (see Fig.1). Since the anomalous transport is predominate, a physical picture of neoclassical transport is not directly applicable to explain experimental observation.

In this study, the poloidal viscous damping rate is explored as a potential key parameter. Generally speaking, zonal flows are generated efficiently in the configuration with low poloidal viscosity and then suppression of anomalous transport is anticipated in such a configuration. The poloidal viscous damping rate $C_p$ [2] is plotted in Fig.1. Since $C_p$ is affected by a toroidal curvature as $\varepsilon_{eff}$, $C_p$ and $\varepsilon_{eff}$ has a clear correlation. Therefore which parameter; $\varepsilon_{eff}$ or $C_p$ is more essential in transport cannot be distinguished. However, plasma elongation can separate these two effects.

Plasma elongation has been controlled by the quadrupole field and scanned in the range between κ=0.8 and 1.4 (see Fig.2). Here elongation is defined by the toroidal averaged value. As seen in Fig.1, a vertically elongated configuration (κ=1.4) has larger $\varepsilon_{eff}$ than the standard configuration (κ=1.0) while it has smaller $C_p$.

Experimental comparison of configurations shown in Fig.2 has been done for the ECH heated plasmas at the magnetic field of 1.5 T. Comparison of experimental energy confinement times with the prediction from the ISS04 scaling is shown in Fig.3. Experimental data align with the scaling for all configurations. Each performance $\tau_E^{exp}/\tau_E^{ISS04}$ is summarized as 0.94±0.02 for κ=0.8, 1.41±0.07 for κ=1.0, and 0.91±0.03 for κ=1.4. If the $C_p$ is more relevant parameter, the confinement should become the maximum at κ=1.4. However, the experiments indicate that the confinement is the best at κ=1.0 and declined by the both prolate(κ=1.4) and oblate(κ=0.8) modifications. The present experimental comparison suggests a negative evidence for relevance of $C_p$.

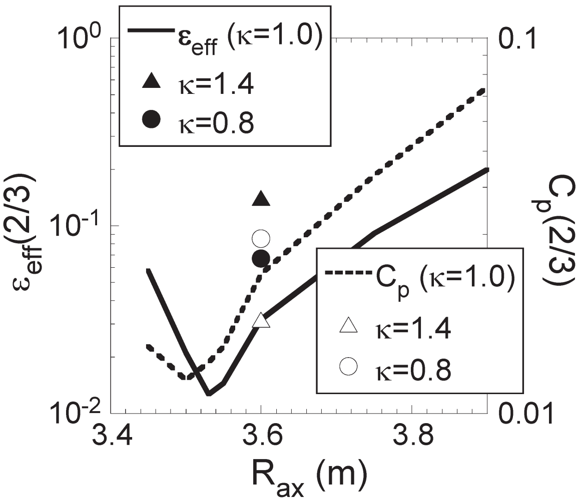


Fig.1 Dependence of effective helical ripple $\varepsilon_{eff}$ and poloidal viscous damping rate $C_p$ on the position o the magnetic axis. Elongation scans are plotted by triangles and circles at $R_{ax}$=3.6m.

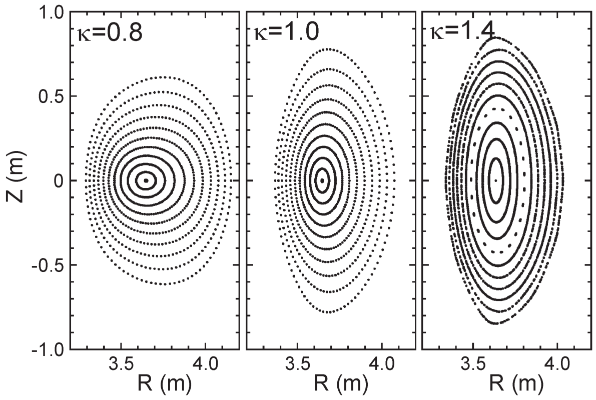


Fig.2 Magnetic flux surfaces for elongation scan. Cross-section at vertical elongated position where the helical coils are located on the equatorial plane.

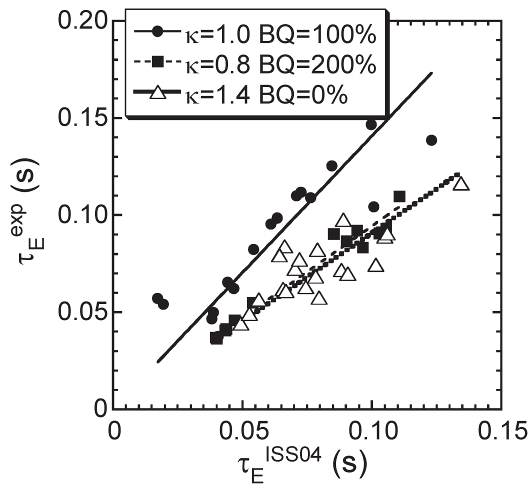


Fig.3 Comparison of experimental energy confinement time with the prediction from the ISS04 scaling.


**References**

[1] H.Yamada et al., Nucl. Fusion **45**, 1684 (2005)

[2] C.D.Beidler et al. Plasma Phys. Control. Fusion **36**, 317 (1994)