§7. Characterization of Energy Confinement Using Extended International Stellarator Confinement Database

Yamada, H., Yokoyama, M., Watanabe, K.Y., Suzuki, Y., Harris, J.H. (Australian National Univ., Australia)
Dinklage, A., Beidler, C.D., Kus, A. (Max-Planck-Institut für Plasmaphysik, EURATOM Association, Germany)
Ascasibar, E., Tribaldos, V. (CIEMAT, Spain)
Sano, F., Murakami, S. (Kyoto Univ.)

International collaboration on development of a stellarator confinement database has progressed. More than 3000 data points from major 9 stellarator experiments have been compiled. In order to express the energy confinement in a unified scaling law, systematic differences in each subgroup are quantified (see Table 1). An a posteriori approach using a confinement enhancement factor on ISS95 as a renormalizing configuration- dependent parameter yields a new scaling expression ISS04 (see Fig.1);

$$\tau_E^{ISS04} = 0.134 a^{2.28} R^{0.64} P^{-0.61} \bar{n}_e^{0.54} B^{0.84} \bar{\iota}_{2/3}^{0.41} \quad .$$

Gyro-Bohm characteristic similar to ISS95 has been confirmed for the extended database with a wider ranger of plasmas parameters and magnetic configurations than in the study of ISS95.

It has also been discovered that there is a systematic offset of energy confinement between magnetic configurations and its measure correlates with the effective helical ripple of the external stellarator field. Another potential geometrical parameter related to a renormalization factor is that given for the neoclassical flux in the plateau regime. This plateau factor corresponds to the effect of elongation in tokamaks. Lackner-Gottardi scaling, which is close to ISS95, was derived from this theoretical approach. An equivalent formulation covering stellarator geometry is available in Ref.[1]. Here the geometrical factor characterizing a particular stellarator is the ratio of the dimensionless fluxes for the multi-harmonic stellarator field to that for tokamaks with only toroidal ripple of *a*/*R*, expressed as $\Gamma_{stell}/\Gamma_{tok}$.

Figure 2 shows the correlation of this plateau factor $\Gamma_{stell}/\Gamma_{tok}$ with the enhancement of confinement times with respect to the unified scaling law ISS04. There seems to be a correlation. However, the plateau factor is closely related to plasma elongation and an elongation scan in LHD (κ=0.8-1.4) has excluded this collinearity, which has not indicated significance of dependence (compare closed and open diamonds in Fig.2). Therefore, ε_{eff} is more likely to be the essential configuration factor than is the plateau factor. It should be noted that both ε_{eff} and $\Gamma_{stell}/\Gamma_{tok}$ are measures of the difference between drift surfaces and magnetic flux surfaces.

Full documentation of the international stellarator confinement database is available at http://iscdb.nifs.ac.jp/ and http://www.ipp.mpg.de/ISS.

Device	f_{ren}
ATF	0.43±0.09
CHS	0.43±0.08
Heliotron-E	0.44±0.09
ATF/CHS/Heliotron E	0.43±0.09
Heliotron-J	0.58±0.23
LHD R_{ax} = 3.6	0.93±0.15
LHD R_{ax} = 3.75	0.67±0.06
LHD R_{ax} = 3.9	0.48±0.05
LHD κ= 0.8	0.71±0.05
LHD κ = 1.4	0.70±0.11
TJ-II	0.25±0.04
W7-A	0.71±0.19
W7-AS $\bar{\iota}_{2/3} < 0.48$	1.00±0.27
W7-AS $\bar{\iota}_{2/3} \geq 0.48$	0.79±0.19
W7-AS high β	0.92±0.18

Table 1 Renormalization factors

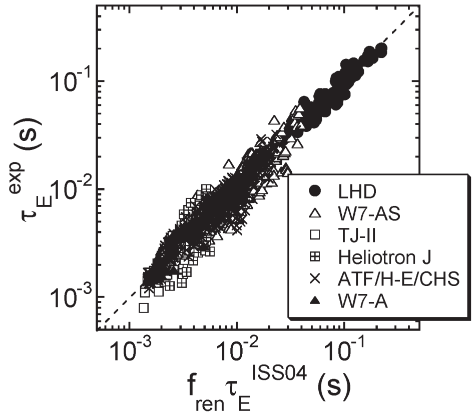

Fig.1 Comparison of energy confinement times in experiments with prediction from ISS04

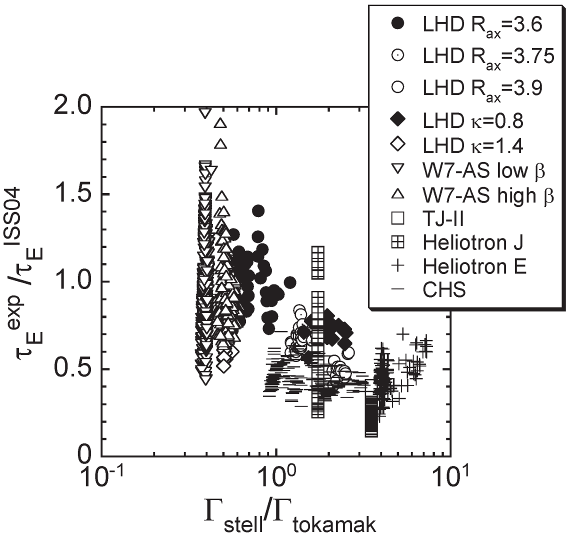

Fig.2 Confinement enhancement factors on ISS04 as a function of $\Gamma_{stell}/\Gamma_{tok}$ at r/a=2/3.

Reference

1) Rodriguez-Solano,R., Shaing,K.C., Phys. Fluids **30** (1987) 462.