

§33. Theory of Improved Confinement in High- $\epsilon\beta_p$ Tokamaks

Fukuyama, A. (Okayama Univ.)
 Itoh, K.
 Itoh, S.-I. (Kyushu Univ.)
 Yagi, M., Azumi, M. (JAERI)

Recently attention has been attracted to the improved confinement modes in high- $\epsilon\beta_p$ plasmas. We have presented a theory of the dynamical interaction between plasma current and plasma pressure under the constant external heating power. They link themselves through the Bootstrap current and thermal conductivity. It is found that the current and pressure cooperatively form a new state of tokamak confinement, if β_p exceeds a value close to unity. This new state has a better confinement time than the L-mode plasma. The confinement improvement is compared to experiments, and the result provides a qualitative agreement with experiments.

We have recently proposed a new theoretical approach to understand the anomalous transport phenomena in tokamaks [1,2]. The formula for the anomalous transport coefficient was derived as

$$\chi = C \frac{q^2}{f(s, \alpha)} \left(-R \frac{\partial \beta}{\partial r} \right)^{3/2} \delta^2 \frac{v_A}{R}$$

where a and R are the major and minor radii, $s = r(dq/dr)/q$, q is the safety factor, α denotes the normalized pressure gradient, $\alpha = -q^2 R \beta' / \epsilon$, δ is the collisionless skin depth. The factor

$f(s, \alpha)$ denotes the influences of the plasma current and Shafranov shift on the anomalous transport. The limiting formula is given in Refs[3]. The numerical coefficient C denotes the uncertainty of the order unity.

The transport simulation was made by use of this formula of the thermal conductivity. The evolutions of the electron temperature, ion temperature and current are solved. The density profile is assumed to be constant in time, and impurities are not considered. Heat deposition profile is fixed.

The enhancement factor is unified in terms of the β_p value. The improved mode is found to occur when β_p exceeds the value close to unity. This increase of τ_E in the low current limit is associated with the flattened current and q -profiles. The sharp reduction of thermal conductivity is formed, in this case, at $r/a \approx 2/3$. Outside of this transport barrier, the thermal conductivity is large as in the L-mode plasma, owing to the large energy flux and small current. However, the Bootstrap current, reduction of shear, and reduced thermal conductivity cooperatively work inside of this radius, and form the transport barrier.

References

- [1] Itoh K, Itoh S-I, Fukuyama A, Yagi M, Azumi M: Plasma Phys. Cont. Fusion **36** 279 (1994).
- [2] Yagi M, Itoh K, Itoh S-I, Fukuyama A, Azumi M: J. Phys. Soc. Jpn. **63** (1994) 10.
- [21] Fukuyama A, Itoh K, Itoh S-I, Yagi M, Azumi M: Plasma Phys. Cont. Fusion **36** (1994) in press.