Isotope effects in internal transport barrier strength on Large Helical Device

NIFS, SOKENDAI, Kyushu University

Introduction

In the case of tokamaks:

- Confinement time scales with the ion mass with the exponent of $\gamma_i = 0.18$-0.3.
- The H-mode power threshold is significantly reduced on D plasmas.

Isotope effects is much clearer in structure formation property than the energy confinement time in tokamaks.

In this contribution, we investigate isotope effects in the confinement structure formation property in LHD by focusing upon internal transport barriers (ITBs)

Profile shape factor as a measure of the ITB intensity

- A toroidal mode (n) = 0.017, a > 0

Profile shape factor ($G_\text{profile}$) is defined as:

$$G_\text{profile} = \frac{\int_0^\infty n(r) dr}{\int_0^\infty n_i(r) dr}$$

Dense plasma confinement

- $n_i$ is the ion density

Role of the radial electric field on the ITB intensity

- Radial electric field is measured by CXS
- The $E_r$ profile shapes are similar regardless of the ITB formation.
- A negative offset exists in the L-mode.

Singularity Value Decomposition (SVD) for radial electric field

- Direct evaluation of the turbulent heat flux $q_\text{h} = \lambda_0 \lambda_1 \gamma_0, \gamma_1$ is difficult.
- As a (imperfect) proxy of the turbulent transport, it measured by PCI is used.
- PCI data were operated only in D cases.

Relation between the turbulence amplitude and the ITB strength

- There are turning points in the turbulence amplitude evolution likely due to ITB formation.
- When $G_{\text{ITB}}$ is small, $n_i/n$ increase with $G_{\text{ITB}}$.
- When $G_{\text{ITB}}$ is large, $n_i/n$ decreases with $G_{\text{ITB}}$.

Summary

1. What kind of isotope effect exists in ITB intensity?
   - Stronger ITBs are formed in the deuterium plasma.
   - An ITB-concomitant edge confinement degradation emerges in the hydrogen plasma.
   - Principal component analysis reveals that the ITB becomes strong when a high input power normalized by the line averaged electron density is applied and electron density profile is peaked.

2. What is the role of the radial electric field?
   - Electric field shear is almost constant regardless of the ITB intensity.
   - Shearing rate ($\sim 10^5 s^{-1}$) of the electric field is one order of magnitude smaller than the linear growth rate.
   - $E_r$ shear may not play a role.

3. What is the role of the turbulence?
   - Density fluctuation amplitude is suppressed when the ITB is formed.