Enhanced confinement and thermal transport decoupling in H-mode plasmas with impurity seeding


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ABSTRACT

• It has been observed that the energy confinement of the H-mode plasma is improved by the edge-deposited impurities in the HL-2A tokamak.
• Both the edge and core ion temperatures are increased by a factor of 20-40% after the SMBI. The reduced edge ion thermal transport leads to the formation a higher edge ion temperature, which is a boundary condition for further increasing the core temperature through the profile stiffness.
• However, the electron temperature is almost unaffected. The results suggest that the ion and electron thermal transport are decoupled by the impurity ions.

BACKGROUND

◆ In magnetically controlled fusion devices, improving plasma performance is crucial for enhancing the confinement efficiency H-mode has been chosen as the standard operating scenario for ITER.
◆ Recently, the energy confinement can be further improved by externally seeded low or medium Z impurities in the H-mode plasmas as observed in several tokamaks.
◆ The impurity seeding experiments suggest that the core-edge plasma coupling is a key process needed to be understood, especially for actively improving plasma confinement.

SMBI system for impurity seeding

Supersonic Molecular Beam Injection (SMBI)
— Better directionality
— Deeper deposition
— Higher fuelling efficiency
— Lower neutral recycling

Calibration results of the number of Ar and Ne SMBI.

CONCLUSION

• In HL-2A, it has been observed that the seeded Ne or Ar gas can reduce the ELM frequency and improve the plasma confinement.
• Both the edge and core ion temperatures are increased by impurity seeding. The core ion temperature stiffness is unchanged.
• The reduced thermal transport leads to the formation a higher edge ion temperature, which is a boundary condition for further increasing the core temperature through the profile stiffness.
• The electron and ion thermal transports are decoupled by the impurity seeding.
• The thermal transport decoupling could plays an important role in the further improvement of core ion temperature in the H-mode plasmas, which is beneficial for burning plasma operation in the future devices.

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