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Effect of magnetic field structure on electron internal transport barrier and its role for the barrier formation in Heliotron J

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The effects of magnetic field topology on an electron internal transport barrier (eITB) and on its formation in the helical plasma are discussed in this paper. In helical plasmas, the eITB can be formed by generation of the positive radial electric field with electron cyclotron resonance heating due to the electron-root transition that is related to the neoclassical transport through the helical ripple. A hypothesis of the eITB formation is that the barrier is easily formed in larger helical ripple (ϵ_{eff}) magnetic configuration. In Heliotron J, however, although the high and low bumpiness configurations have higher ϵ_{eff} compared to the medium bumpiness configuration, the power thresholds to form the eITB in the low and high bumpiness configurations are larger ($\sim 550 \times 10^{-19} kWm^3$) than that of the medium bumpiness ($\sim 250 \times 10^{-19} kWm^3$). This result shows that the eITB formation is not determined by ϵ_{eff} alone. Next, we have investigated the effect of the magnetic topology on the eITB formation. The first result is that the correlated behaviors of the eITB foot point and the low-order rational surface location are observed. The former shows a jump at $I_p \sim 0.7kA$ and a subsequent outward shift by the current increase. The estimated 4/7 rational surface appears at the value of $\sim 0.7kA$, then it moves outward with the increase of the bootstrap current. The second result is that the power threshold for the eTIB formation is reduced from $265 \times 10^{-19} kWm^3$ to $240 \times 10^{-19} kWm^3$ when the plasma current increases above $I_p \sim 0.9kA$, of which value is almost the same as the calculated value that is required to form 4/7 rational surface. Because the 4/7 rational surface is a candidate on which the magnetic island can be formed due to the n=4 toroidal periodicity of the vacuum magnetic field, and other low-order rational surfaces have no contribution to these phenomena, the results show the possibility that the formation of the magnetic island can expand the improved confinement region or reduce the power threshold for the eITB formation. The similar mechanism that the magnetic island affects the plasma transport has been also observed in numerical simulation. It is necessary to consider not only neoclassical transport effect but also magnetic island effect on the eITB formation.

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