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Improvements of ion energy confinement in helium rich plasma of LHD

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The improvement of the ion energy transport was observed in the He rich plasma of LHD. The ion thermal diffusivity around the edge pedestal region is lower than that of the gyro-Bohm prediction taking into account the effective ion mass and charge. The transport of different ion species is an important issue to predict the performance of ITER and the future reactor operation. In this paper, we report the results of a systematic study of effective ion mass and effective ion charge on ion energy transport of ion ITB plasma in LHD. With constant NB heating power (20-23MW) at the same line averaged electron density (1.35x10ˆ19mˆ-3), clearly higher Ti was observed at higher He concentration plasma. The fueling ratio R, which is defined as R=nH/(nH+nHe) were controlled by the discharge cleaning and external gas fueling. R changed from 0.34 to 0.79. At lower R (with higher He concentration), total ion density ni, which was consist of nH+, nHe2+ , nC6+, became lower. However, ion deposition powers per ion (Pi/ni) were almost constant for different R. Thus, the achieved higher Ti at lower R is not due to the difference of Pi/ni but due to the improvements of ion energy transport at lower R (He rich plasma). The Ti profiles shows edge pedestal formation both in He rich and H rich plasma. But Ti at pedestal top at rho˜0.9 was higher in the He rich plasma. While in the inner region (rho<0.9), the normalized Ti gradients were almost constant for different R. At rho=0.4-0.9, ion scale turbulence (kperp rho_i˜0.4) were observed. The linear gyrokinetic analysis showed ITG was the dominant instability. Thus, within the Ti pedestal (rho<0.9), it is likely that the normalized Ti gradient is limited by ITG threshold. The effective ion thermal diffusivities (chi_i_eff), which is the representative ion thermal diffusivity of H+,He2+ and C6+, were estimated from the power balance analysis. When chi_i_eff is normalized by the gyro-Bohm factor, which is mieffˆ0.5,Tiˆ1.5/(qieffˆ2), where mieff is effective ion mass, qieff is the effective ion charge, the normalized chi_i_eff is almost identical at rho<0.8 for different R, while the normalized chi_i_eff is clearly lower at lower R (larger He contamination). This suggests transport improvements in edge region and corresponds to the higher edge Ti pedestal in He rich plasma.

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