Isotope effects in linear and saturated ohmic confinement of TCV tokamak and their validation with gyrokinetic modelling

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Isotope effects are investigated in TCV ohmic discharge of diverted configuration of normal triangularity shape with deuterium (D) and hydrogen (H) plasma. The transition from Linear Ohmic Confinement (LOC) regime to Saturated Ohmic Confinement (SOC) regime were clearly identified from the shot by shot density scan experiments. Transport are almost identical in LOC regime, while clear improvements of heat and particle transports were found in SOC regime. In SOC regime, global energy confinement is higher in D plasma. Also, higher electron and ion temperatures were found for identical electron heating power and lower ion heating power in SOC regime of D plasma suggesting reduced electron and ion heat transport.Measured lower particle source in SOC regime in D plasma suggests better global particle transport. Density modulation experiments were performed and diffusion coefficients(D_{mod}) and convection velocities (V_{mod}) were separately evaluated. D_{mod} and V_{mod} were almost identical in LOC regime in H and D plasma. While in SOC regime, D_{mod} and inwardly directed V_{mod} were lower in D plasma.

Non-linear gyrokinetic modelling were performed at ρ_{tor}=0.5 for kρ_i=0.3-3.1. In non-linear gyrokinetic modelling, saturated heat and particle fluxes are sensitive to input gradient. Thus, at first, switching of ion species were carried out keeping other input parameter constant for the investigation of isotope effects. In LOC regime, electron and ion heat fluxes are almost identical for H and D plasma. In SOC regime, electron and ion heat fluxes are lower in D than in H plasma. These results qualitatively agree with experimental observation. Then, effect of E×B shearing rate and collisionality were switched on and off in SOC plasma. E×B shear reduced electron and ion heat fluxes in H and D plasma, however, isotope effects of E×B shear was not visible. The isotope effects of collisionality stabilization effects were clear and is likely to be main mechanism of observed isotope effects. Finally, validation study using experimental profiles were performed for SOC plasma. Experimentally, electron heat flux is higher in D and ion heat flux is higher in H plasma. Non-linear electron heat flux with E×B shearing effects was around 70% experimental value both in H and D plasma. Non-linear ion heat flux of D plasma with E×B shearing effects agrees with experimental value within simulation uncertainty. However, non-linear ion heat flux of H plasma was strongly underestimated and was 30% of experimental values. Then, the normalized ion temperature gradient was increased by 20%, which is uncertainty of the measurements. The ion heat flux became 70% of experimental value, however, electron heat flux was overestimated and was 2.8 time of experimental values. Tuning of gradient did not reach the simultaneous agreement of electron and ion heat flux in H plasma. The results of density modulation was validated as well for SOC plasma. For this validation, the normalized non-linear electron particle flux was evaluated using experimental values and zero normalized density gradient. The slope of two particle fluxes shows D_{mod} and y-intercept shows V_{mod}. Experimentally observed lower D_{mod} and lower inward V_{mod} in D plasma was reproduced by simulations. Agreements with D_{mod} and V_{mod} were found for SOC H plasma within measurements and simulation uncertainty, however, simulated D_{mod} in D plasma was factor four higher and inward V_{mod} was factor two lower than experimental values.