CORE TURBULENCE AND TRANSPORT REDUCTION IN DIII-D DISCHARGES WITH WEAK OR NEGATIVE MAGNETIC SHEAR*

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Core turbulence fluctuation levels have been suppressed in DIII–D discharges with weak or negative magnetic shear. In some weak magnetic shear discharges with an H–mode edge, the ion thermal transport has been reduced to neoclassical levels throughout the whole plasma. In these discharges the particle transport remains unchanged. In other discharges with an L–mode edge and strongly negative central magnetic shear, particle and ion thermal transport are suppressed but only near the center of the plasma. Electron thermal transport suppression is also sometimes observed. The cause of the transport reduction is investigated by calculating the stability of toroidal drift waves i.e. ion temperature gradient (ITG) modes, trapped electron (TE) modes and electron temperature gradient (ETG) modes with a comprehensive gyrokinetic linear stability code. It is found that the ITG and TE modes are stabilized by E×B velocity shear in all of the DIII–D regimes which have ion thermal transport reduction. The expansion of the region where E×B velocity shear is larger than the maximum growth rate of the dominant ITG or TE mode is primarily responsible for the spontaneous growth of a region of suppressed ion thermal transport. Surprisingly, the negative magnetic shear is only a weak stabilizing influence for the ITG and TE modes in the DIII–D cases studied. Negative or weak magnetic shear does eliminate the ideal magnetohydrodynamic ballooning mode instability which would otherwise limit the energy confinement. Negative magnetic shear, together with a large Shafranov shift, can stabilize ETG modes which may explain the improved electron thermal transport sometimes observed. The ETG modes are not stabilized by E×B velocity shear due to their high frequency. Dilution of the thermal ions by fast ions from the heating beams and hot ions compared to electrons are found to be important stabilizing influences in the core which both reduces the E×B velocity shear required for stability and broadens the region of reduced transport. The thermal ion density is often hollow near the center due to fast ion dilution. This enhances the E×B velocity shear. The lack of an improvement in particle transport in some cases where ion thermal transport is reduced is contrary to the quasi-linear theory prediction for the toroidal drift waves considered.

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