Non-linear gyro-kinetic Ion Temperature Gradient (ITG) and Trapped Electron Modes (TEM) turbulence modelling in X-point geometry in negative and positive triangularity shapes.

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Sufficiently strong negative triangularity (NT) shaping of tokamak plasma prevent the bifurcation to H-mode while leading to high confinement regimes similar to H-mode plasmas but without Edge Localized Modes (ELMs) [1-2]. It could be a promising regime for fusion reactor. In the recent theoretical and numerical studies the conclusions vary depending on the physics included in either local, global, linear or non-linear models, plasma profiles and type of turbulence considered. The most general conclusion by now is that NT shaping is mainly stabilizing for the Trapped Electron Modes (TEMs) [3-5] and possibly also for Ion Temperature Gradient (ITG) modes [7].

The recent results of the comparative modelling of negative (NT) and positive (PT) triangularity plasmas will be presented. The non-linear global gyro-kinetic particle code JOREK-GK [8-9] in the realistic X-point tokamak geometry including Scrape Off Layer (SOL), divertor and walls was used. The equation of motion of gyro-centers of ions is solved in a time varying gyro-averaged electric field and time-constant magnetic field. The kinetic electrons follow the guiding center orbits. Electron-ion collisions are included in the model.

To begin, the comparison of JOREK-GK code with gyro-kinetic codes GS2 [4], GENE-X and GENE [5] was done on a few selected NT/PT triangularity TCV–like parameters. It showed good agreement between codes in linear growth rates of ITG/TEM modes in linear phase and clear beneficial effect of NT as compared to PT. Next, the global non-linear modelling of the ITG/TEM saturated turbulence for realistic DIII-D NT pulses was done and compared with constructed "mirror-flipped" PT equilibrium with the same plasma profiles. The larger time-space correlation of density fluctuations at PT compared to NT was demonstrated explaining larger turbulence and heat fluxes at PT. The direct comparison with experimental heat conductivities and Doppler Backscattering (DBS) measurements of density fluctuations correlation and edge poloidal ExB velocity in DIII-D showed a good agreement with JOREK-GK modelling. Weak dependence of plasma confinement on collisionality was found in NT. Counter-current plasma rotation is stabilizing factor for the edge turbulence since it increases the shear of the poloidal ExB flow. Finally, the confinement scaling with normalized ion radius ρ^* was estimated both for NT and PT. Bohm-like scaling was obtained in both configurations, however with better confinement for NT compared to PT which could be favorable factor for reactor size machines with high confinement operation without harmful ELMs.

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