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Single Null Divertor in Negative Triangularity Tokamak

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Fusion research has to solve the power handling problem toward fusion demonstration reactor (DEMO). Tokamak plasma with negative triangularity and an outboard divertor X-point may offer such an opportunity as an innovative concept. The present paper extends this concept investigating single null negative triangularity tokamak (SN-NTT). Double null negative triangularity tokamak (DN-NTT) configurations feature quite high stable pedestals in the 1st region of ballooning stability but the vertical stability is an issue for the DN-NTT. Already with one outboard X-point in the SN-NTT internal modes set the pedestal height limit. The changes in ELM regime, pedestal structure and Mercier mode driven turbulence are major issues yet to be investigated for the negative triangularity tokamak concept. Studying such phenomena from first principles would require nonlinear, electromagnetic gyrokinetic simulations.

While negative triangularity plasma has some favorable MHD property with respect to ELMs, the beta limit is relatively low. That is connected with the absence of magnetic well for elongated plasma cross-sections. However, negative triangularity tokamak configurations with optimized pressure gradient profiles can be stable for betaN>3 at elongation k=1.8 and internal inductance li=0.9, even in the absence of the magnetic well, with Mercier modes stabilized by magnetic shear in the SN-NTT with the optimal upper triangularity value close to zero.

Apart from the ELM mitigation and satisfactory level of beta limits, negative triangularity tokamaks feature other possibilities for power handling such as naturally increased separatrix wetted area due to divertor location at larger radii and more flexible divertor configuration using PF coils inside the TF coil made of NbTi superconductor in the low field region. Negative triangularity experiments in TCV show a reduction in electron heat transport by a factor two compared with positive triangularity D-shaped configurations, which is partly explained by nonlinear gyrokinetic simulations. This configuration also allows better pumping accessibility due to larger conductance. Engineering restrictions on toroidal field (TF) coils at the high field side may not allow the TF shape conformal to negative triangularity plasma: more realistic race-track shaped TF coils are better compatible with the SN-NTT configuration.

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