# The negative triangularity effects on the safety factor profile for tokamak steady state confinement

Linjin Zheng, M. T. Kotschenreuther, F. L. Waelbroeck, and M. E. Austin
Institute for Fusion Studies, The University of Texas at Austin,
Austin, TX 78712, USA

There is renewed interest in the negative triangularity (NT) tokamaks. The TCV and DIII-D experiments found that the low (L) mode discharges in the negative triangularity discharges can reach about the same level beta normal as the H mode confinement [1,2]. Since they are L mode discharges, there are no ELMs. Furthermore, the turbulence level in NT is considerably lower than typical L mode discharges. These observations are found to be consistent with the MHD stability analyses with the AEGIS and DCON codes for DIIID-like equilibria [3,4]. Further investigation of NT configuration in Ref. [3] points out another distinguished and important feature: the NT configuration can generate the rotation transform of magnetic field lines more effectively. It indicates that the NT configuration is potentially preferred for the advanced tokamak scenario with high fraction of bootstrap current and steady-state confinement. In this work, we further exploit this feature. We first use the semi-analytical method to examine how the positive and negative triangularity affects the safety factor profile with the Solovev equilibrium solution. The X point effects are taken into account in this case. The local and nonlocal field line rotation transform will be examined and their effects on the stability will be assessed. The bootstrap current will be introduced afterwards to exploit the possibility of steady state confinement. The comparison with the numerical equilibria with VMEC and ATEQ will also be discussed. This research is supported by Department of Energy Grants DE-FG02-04ER54742.

[1] Camenen Y. et al 2007 Impact of plasma triangularity and collisionality on electron heat transport in TCV L-mode plasmas, Nucl. Fusion **47** 510-16.

[2] Austin M. E. et al. 2019 Achievement of Reactor-Relevant Performance in Negative Triangularity Shape in the DIII-D Tokamak, Phys. Rev. Lett. 122 115001.

[3] Linjin Zheng, M.T. Kotschenreuther, F.L. Waelbroeck W. L. Rowan, P. Valanju, and X. Liu 2018 The negative triangularity effects on tokamak MHD stability, IAEA-FEC, TH/P5-31.

[4] Linjin Zheng, M.T. Kotschenreuther and F.L. Waelbroeck 2021 Intermediate n mode stability in the negative triangularity tokamaks, Nucl. Fusion **61** 116014.