3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Advances in physics basis of L-mode edge negative triangularity tokamak reactor

M. Kikuchi[1,2,8], T. Takizuka[3],S. Medvedev[4], M. Austin[5], O. Sauter[6], L. Villard[6], A. Merle[6], M. Fontana[6], J.X. Li[2], D. Chen[7], T. Ando[8]

[1]ILE-Osaka University, [2]SWIP, [3]Osaka University, [4]KIAM-RAS, [5]IFS-U.Texas, [6]SPC-EPFL, [7]INEST, [8]Ex-JAEA

e-mail:aapps.dpp.ceo@gmail.com

Negative-triangularity Tokamak Reactor [1, 2, 3] is an innovative reactor concept based on "power-handling-first" philosophy based on TCV's pioneering work [4]. Quite recently, DIII-D [5] achieved reactor relevant performance (β_N=2.7, H_H=1.2) in negative triangularity (NT) shape. Importantly, DIII-D high performance NT plasma exhibits L-mode edge while positive triangularity (PT) plasma undergoes limiter H-mode transition [5]. Values of P_{heat}/P_{LH} in DIII-D NT and PT shaped plasmas are both ~6.7 and NT stays in L-mode edge and PT made L–H transition. There seems a resilience to stay in L-mode edge in NT shape (see Figure 1).

The ratio of transport power to L-H threshold P_{trans}/P_{LH} is 2.6-3.5 in our recent designs of L-mode edge NT Tokamak reactor [3]. Thus, there might be a possibility of NT Tokamak reactor stay in L-mode edge.

As we discussed in 2013 in US-TTF [6], current problems on power and particle exhausts is originated from the H-mode operation. L-mode edge, if it is feasible, is robust and has higher particle exhaust capability and hence heat exhaust/particle is expected to be lower than in H-mode.

Edge turbulence is expected to be lower in NT than in PT shape if it is driven by the resistive ballooning mode [7], which implies turbulent drive for the Zonal flow. Due to geometrical structure, NT may have less toroidal coupling to produce GAM. Since flow shear and GAM/zonal flow plays an important role in L-H transition [8], experimental and theoretical investigation of GAM/zonal flow in NT is crucially important.

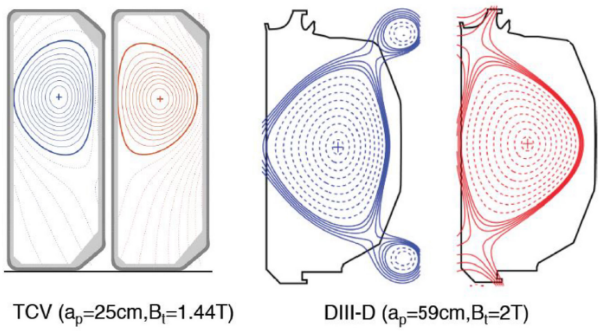

Figure 1 D-shaped and NTT experimental configurations in TCV (PT:S = 9.9 m^2, NT:10.3 m^2) and DIII-D (PT:S = 42 m^2,NT: S = 45 m^2). Here S is plasma surface area.

Recent design of L-mode edge NT Tokamak reactor [3] (see Figure 2) showed that length along the divertor plate to receive heat from the reactor can be as much as 20 mm if the SOL width of L-mode edge is twice as large as H-mode.

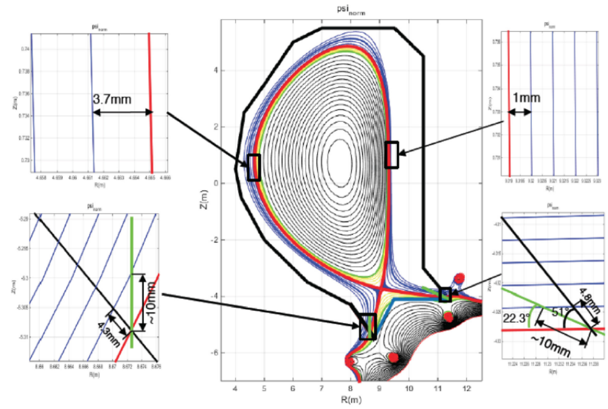

Figure 2 Divertor geometries for NTT (I_p = 15 MA, R_p = 7 m, I_{FTE} = 2.5 MA). For a 1 mm SOL width at outboard mid-plane, inboard mid-plane thickness is 3.7 mm. Use of FTE coils expanded the flux tube and 4–5 mm along the divertor plate for the original semi-open divertor target geometry (black lines). With more inclined divertor targets, 1 mm SOL at outboard mid-plane will be projected to 10 mm along the divertor plates (green lines).

References

[1] Kikuchi, M., et al., 2014 Negative triangularity tokamak as fusion energy system *1st Int. E-Conf. on Energies (14 March 2014)* p E002(http://sciforum.net/conference/ece-1/paper/2321)

[2] Medvedev, S. Yu. et al., 2015 The negative triangularity tokamak: stability limits and prospects as a fusion energy system, *Nucl. Fusion* **55** 063013

[3] Kikuchi, M. et al., 2019 L-mode-edge negative triangularity tokamak reactor, Nucl. Fusion **59** 056017

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

[5] 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

[6] Kikuchi M. and Takizuka T. 2013 Is H-mode relevant for fusion reactor *US-EU TTF 2013 (Santa Rosa, USA, 2013)* (http://ttf2013.ucsd.edu/TTF_Meeting/Presentations.html)

[7] Riva F., Lanti E., Jolliet S. and Ricci P. 2017 Plasma shaping effects on tokamak scrape-off layer turbulence *Plasma Phys. Control. Fusion* **99** 035001

[8] G. Tynan, Fundamental studies of fusion-relevant turbulent transport and plasma self-organization physics in a linear plasma device, Plenary talk at 1st Asia-Pacific conference on plasma physics (http://aappsdpp.org/DPP2017rogramlatest/wholeitem/plenary/3285P24.pdf) P24-DPP2017