Contribution ID: **69** Type: **Poster**

Scoping study of dissipative divertor scenarios for SPARC

Wednesday 6 November 2019 18:15 (15 minutes)

Operating at 12 tesla on axis with a plasma current of 7.5 MA and total fusion power of 100 MW, SPARC [1] is projected to have a power exhaust heat flux width of 0.2 mm with an unmitigated parallel heat flux of up to 30 GW m-2 entering the divertor. While recent UEDGE modelling of other high-field tokamaks designs, ADX and ARC, indicates that long-leg divertors can dramatically improve divertor power handling –producing fully detached solutions with benign power fluxes to material surfaces [2,3] –SPARC does not have a neutron shield blanket and therefore only has limited space for the divertor legs. Consequently, the current approach for mitigating target heat fluxes is to take advantage of whatever divertor dissipation may be available and rapidly sweep the strike point over a large divertor target area while employing large target plate tilt angles.In this present study, we use UEDGE to examine the level of divertor dissipation that may be obtained in SPARC for representative divertor leg lengths and target plate geometries. UEDGE is set up to match the SPARC design dimensions and projected upstream plasma parameters and the exhaust power flux; then the numerical solutions for the divertor are analyzed varying details of the divertor geometry (the leg length, target plate tilting) and plasma physics assumptions (anomalous transport in the leg, impurity ion radiation) to determine whether fully- or partially-detached divertor plasma scenarios exist and at what power exhaust levels.

[1] Greenwald et al. "The High-Field Path to Practical Fusion Energy"MIT PSFC report PSFC/RR-18-2 (2018); [2] Umansky et al., Phys. Plasmas 24 (2017) 056112; [3] Wigram et al., Contrib. Plasma Phys., 58 (6–8) (2018), p. 791

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Session Classification: Poster Session III

Track Classification: Radiative Power Exhaust