The intermittent SOL: Setting plasma performance and power handling

V. Naulin

DTU Fysik, Plasma Physics and Fusion Energy group, Byg 309, DK 2800 Lyngby

vona@fysik.dtu.dk

The region of open magnetic field lines in tokamaks, which establishes the contact of the confined plasma with material surfaces, has often only been perceived as a boundary condition to the core plasma, with the main effect of providing a source of impurities. In the recent years, it has become increasingly clear that the SOL is setting the conditions for core plasma performance and confinement transitions between low and high confinement.

Simulations dropping the distinction between fluctuations and background have been highly successful in reproducing crucial features of the SOL without the input of fitting parameters. Both transitions to H mode with intermittent access to the H mode have been demonstrated and selected power scalings have been recovered. More recently the fuelling of fusion plasmas and the influence of the particle source region in the plasma edge has gained vast attention. Experimental and numerical investigations are underway to understand the effects of SOL intermittency on fuelling and eventual inward pinch effects through the pedestal and via the X-point. The statistical properties of the SOL fluctuations are now well established and can be described as a super-position of uncorrelated pulses from the confinement region into the SOL domain.

The saturation of the SOL profiles, that is shoulder formation and their potential connection with plasma detachment and HL back transition, has gained attention as detachment needs to be obtained to mitigate power loads in any realistic divertor operation regime with stable H-Mode operation.

The theoretical explanation of the observed heat loads to the divertor and first wall elements and their extrapolation towards ITER conditions is challenging and needs support from accompanying numerical simulations. Large-scale kinetic simulations give stimulating input, but ultimately systematic scans of the parameter space in operating tokamaks are mandatory. The inclusion of finite temperature ion dynamics and neoclassical effects were successful for connecting empirical results to physics interpretation, revealing the role of zonal flows for the initial access to H mode and reproducing SOL fall off lengths,

While much progress has been obtained in understanding the non-local and intermittent nature of the SOL, large gaps in our understanding remain, specifically the interaction with neutrals and plasma facing components especially divertor regions. Many species plasmas and most certainly geometry effects will be the areas where most development is expected. We here review recent experimental findings and contrast them with present simulation results including the effects of neutral turbulence interaction.