A quantitative description of thermal transport in the SOL of ASDEX Upgrade

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The need to predict heat fluxes onto the different plasma facing components is important for the design of a reactor-relevant tokamak. In recent years, substantial experimental effort has been dedicated to the evaluation of convective particle fluxes associated to filaments, which are widely considered to dominate transport in the far SOL. In ASDEX Upgrade (AUG), filaments were found to transit into a disconnected regime when divertor collisionality exceeded a certain threshold, leading to an enhanced perpendicular particle transport in the outboard midplane. This process has been clearly linked with the flattening of the SOL density profiles known in the literature as “shoulder formation”. However, few works have attempted to provide a quantitative description of the perpendicular and parallel heat fluxes in the far SOL, and their relation to different transport regimes. Therefore, the role of filaments on heat transport and the effect of such transition into an enhanced transport regime remain largely unknown. In particular, it is unclear whether filaments are able to advect significant amounts of energy and thus should be taken into consideration when assessing plasma-wall interaction aspects such as divertor loads or main wall sputtering. Similarly, enhanced filamentary convection is frequently considered to change the perpendicular to parallel transport ratio. However, a direct experimental comparison of these two terms has seldom been carried out to justify such assumption.

In this work, we set out to answer these questions: By combining data from different experiments carried out in equivalent plasma configurations in AUG, we have created a data base of all relevant SOL plasma parameters including density, electron and ion temperature, filament velocity, parallel Mach number, etc. With this information, a comprehensive calculation of particle and heat fluxes in the far SOL is carried out, and perpendicular and parallel transport are evaluated for different filamentary regimes. By these means, it is concluded that a substantial fraction of the power crossing the separatrix is advected by filaments in the perpendicular direction, beyond the near SOL. Likewise, the shoulder formation is found to be associated to a substantial increase of the perpendicular to parallel particle and heat flux ratio.