Kinetic effects in tokamak scrape-off layer plasmas - nonlocal parallel transport and plasma-atomic reactions

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In tokamak scrape-off layer (SOL) plasmas, accurate modelling of heat transport to the divertor region and plasma-facing components is critical to the successful operation of future devices. These plasmas are often assumed to be highly collisional, so Braginskii-like fluid models are used. However, there are two important aspects of SOL physics for which this assumption may be violated. First, the presence of steep parallel temperature gradients, as would be expected in devices like ITER, means electron heat transport may be dominated by fast, low-collisionality particles and so becomes 'non-local'. Secondly, enhanced high-energy tails of electron distributions close to the walls, where most plasma-atomic interactions take place, may modify reaction rates (e.g. electron-impact ionisation), and therefore affect the particle, momentum and power balance.

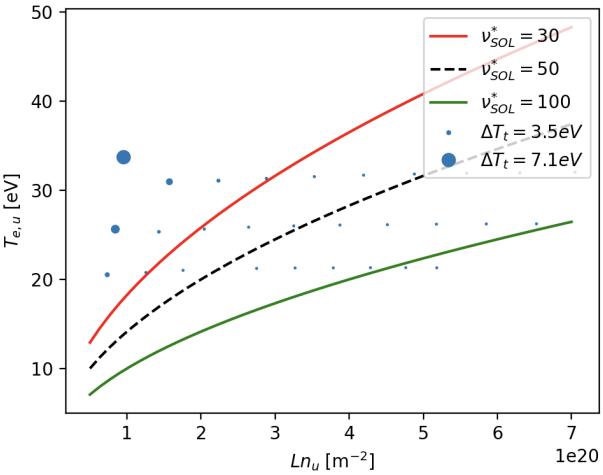

Figure 1: *Difference in target temperature for SOL simulations with kinetic vs. fluid electrons.*

For these reasons, electron kinetics in SOL plasmas has been investigated using the 1D code SOL-KiT [1]. SOL-KiT has been extended to model background ions and neutral atoms more realistically, with the aim of studying SOL plasmas in reactor-relevant conditions. Results from simulations will be presented comparing fluid and kinetic electron treatments, looking in particular at modifications to the electron heat flux and atomic reaction rates. To ascertain the tokamak regimes where kinetic effects may be most important, we have performed upstream collisionality scans, looking at both equilibrium and transient/ELM-y conditions. We find large differences in electron heat conductivity at reactor-relevant collisionalities, as well as small modifications to plasma-neutral reaction rates with atomic hydrogen.

References

[1] S. Mijin, F. Militello, S. Newton et al. Plasma Phys. Control. Fusion **62**, 9 (2020)