Introduction of a multi-species collision operator in GT5D and its application to heavy impurity transport

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The use of tungsten to coat divertors or other plasma facing components, as will be the case for ITER, inevitably leads to the pollution of the fusion plasma by heavy and highly charged impurities. Several tokamaks (ASDEX Upgrade, JET) have reported on-axis accumulation of tungsten – which would be detrimental to fusion efficiency – and its exhaust by electron heating. However, this kind of neoclassical and turbulent transport of high-Z impurities is not yet fully understood.

To better treat heavy impurities, the gyrokinetic full-f Eulerian simulation code GT5D [1] was recently upgraded with an implicit collision solver based on a multi-species linear Fokker-Plank collision operator [2]. In addition, a flux-coordinate version of the code was developed to accelerate neoclassical simulations and quasi-local turbulence simulations in shaped magnetic configurations.

A prior neoclassical benchmark for bulk ions between GT5D and the Hirschman-Sigmar (HS) theory [3] was extended to various impurities in all transport regimes. While a standard low order approximation of the HS theory [4] showed good agreement for light impurities, large differences were observed in the presence of moderate or large temperature gradients. Instead, under such conditions, we tested an improved form of the HS theory [5], that takes into account higher order flows to more accurately recover the friction coefficients in the Pfirsch-Schlüter regime, showing good agreement with GT5D.

References

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