Fast isotope mixing in Ion Temperature Gradient driven turbulence

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Recent multiple-isotope experiments at JET have found evidence for ion particle transport coefficients larger than electron particle transport coefficients [1]. We apply GKW [2] nonlinear and QuaLiKiz [3] quasilinear modelling to show the consistency with expectations of particle transport in the Ion-Temperature-Gradient (ITG) driven regime. The effect is explained through the dependency of particle transport coefficients on the wave-particle resonance condition [4]. In spite of the disparity in particle transport coefficient magnitude, ambipolarity is maintained by large inward ion convective pinches being compensated by the large outward diffusion. In multiple-ion experiments, the ambipolarity condition can be matched by the summation of multiple ion fluxes, providing for additional freedom where the large ion transport coefficients can then provide fast ion mixing. We illustrate these ramifications for multiple-isotope transport through JETTO [5, 6] integrated modelling with QuaLiKiz, through numerical experiments based on a well modelled JET-ILW baseline discharge [7]. The large ion particle transport coefficients implies that the ion density profiles are uncorrelated to the corresponding ion source, allowing peaked isotope density profiles even in the absence of core source. Furthermore, the relaxation time of the individual ion profiles in a mixed system can be significantly faster than the total density profile relaxation time which is constrained by the electrons. This leads to fast isotope mixing and fast impurity transport in ITG regimes. In Trapped-Electron-Mode (TEM) turbulence, the situation is the inverse: ion particle turbulent transport coefficients are smaller than their electron counterpart.

References

[1] M. Maslov *et al.,* to be submitted to Nucl. Fusion; M. Marin *et al., this conference*.
[2] A. Peeters *et al.,* 2009 *Computer Physics Communications* **180** 12.
[3] C Bourdelle *et al.* 2016 *Plasma Phys. Control. Fusion* **58** 014036.
[4] C. Bourdelle, Y. Camenen, J. Citrin, M. Mirin *et al.,* to be submitted to Nucl. Fusion.
[5] G. Cenacchi, A. Taroni, JETTO: A free-boundary plasma transport code, JET-IR (1988).
[6] M. Romanelli *et al.* 2014 Plasma and Fusion Research Volume 9, 3403023.
[7] J Citrin *et al.,* 2017 *Plasma Phys. Control. Fusion* **59** 12.