Collisional stabilisation of trapped electron modes in tokamaks: pitch angle scattering vs energy scattering

P. Manas[1], Y. Camenen[1], S. Benkadda[1], W.A. Hornsby[2], A.G. Peeters[2]

[1] Aix-Marseille Université, CNRS, PIIM UMR7345, 13397 Marseille, France
[2] Department of Physics, University of Bayreuth, 95440 Bayreuth, Germany

In tokamaks, trapped electron modes (TEM) are known for long to be stabilised by collisions. Indeed, by de-trapping electrons, collisions prevent the resonance between the bouncing motion of the trapped electrons and the mode (see e.g. [1, 2]). Collisions are described by the Landau collision operator [4] which satisfies the H-theorem, conservation of particle, momentum and energy. The test particle part (collisions with a Maxwellian background), can be written as [5]:

$$C_{ab} = (f_a, f_{b0}) = \nu_D^{ab}\mathcal{L}(f_a) + \frac{1}{v^2}\frac{\partial}{\partial v}\left[v^3\left(\frac{m_a}{m_a+m_b}\nu_s^{ab} f_a + \frac{1}{2}\nu_\parallel^{ab} v\frac{\partial f_a}{\partial v}\right)\right] \tag{1}$$

with ν_s^{ab} the slowing down frequency, ν_D^{ab} the deflection frequency and $\nu_\parallel^{ab}$ the parallel velocity diffusion frequency.

Many turbulent transport studies are carried out with a simplified test particle collision operator which only takes into account the pitch angle scattering (i.e $\nu_D^{ab}\mathcal{L}$) as it is sufficient to obtain TEM stabilisation by collisional detrapping. However, a full test particle operator including energy scattering can also play a non negligible role in the stabilisation of TEM. Simulations were performed with the gyrokinetic code GKW [3] which solves the gyro-averaged Vlasov equation including pitch angle scattering and energy scattering in the linearised Landau operator: $C_{ab}(f_a, f_{b0}) + C_{ab}(f_{a0}, f_b)$. The importance of conservation properties through a well defined field particle operator is emphasized. It is shown that energy scattering enhances the stabilisation of TEM, especially when the mode frequency is low. This impacts the ITG/TEM transition and the subsequent modifications of the particle, momentum and heat fluxes.

References

[1] M.A. Beer, *Ph.D. thesis, Pinceton University* (1995)

[2] F.Y. Gang and P.H. Diamond, *Phys. Fluids B* **2**, 2976 (1990)

[3] A.G. Peeters, Y. Camenen, F.J. Casson, W.A. Hornsby, A.P. Snodin, D. Strintzi, G. Szepezi, *Computer Physics Communications* **180**, 2650 (2009)

[4] L.D. Landau, *Physikalische Zeitschrift der Sowjetunion* **10**, 154 (1936)

[5] P. Helander, D.J. Sigmar, *Collisional transport in magnetized plasmas*