Turbulent acceleration and heating in toroidal magnetized plasmas

X. Garbet[1], D. Esteve[1], Y. Sarazin[1], J. Abiteboul[1], C. Bourdelle[1], G. Dif-Pradalier[1], P. Ghendrih[1], V. Grandgirard[1], G. Latu[1], A. Smolyakov[2]

[1] CEA, IRFM, F-13108 St.Paul-lez-Durance cedex, France
[2] Department of Physics and Engineering Physics, U. of Saskatchewan, Canada.

Turbulent heating is known as a potential source of energy transfer from electromagnetic waves to particles in magnetized plasmas [1,2]. It is shown here that turbulence can also provide a source of momentum in a tokamak, which cannot be recast as a divergence of a momentum flux, and was not addressed previously. This process is similar to turbulent heating, with similar properties [3]. The sum over all species vanishes up to polarization contributions. Hence toroidal momentum is transferred from species to species, This process is mediated by turbulence. As well known for momentum transport, symmetry breaking is needed. Flow shear is investigated as a source of symmetry breaking, leading to a source of momentum proportional to the shear rate. Turbulent acceleration is significant for ion species. It is found that it is proportional to the charge number Z, while turbulent heating scales as Z^2/A, where A is the mass number. It is maximum in the edge where the ExB flow shear rate and turbulence intensity are maximum. When both intensity and shear rate are large enough, the turbulent torque may overcome the collisional friction between impurities and main ions, thus leading to different toroidal velocities. This has deep implications on velocity measurements and confinement.

References

[1] E. Ott, J. B. McBride, J. H. Orens, and J. P. Boris, *Phys. Rev. Lett.* **28**, 88 (1972).

[2] W. M. Manheimer, E. Ott, and W. M. Tang, *Phys. Fluids* **20**, 806 (1977).

[3] X. Garbet, D. Esteve, Y. Sarazin, et al., *Phys. Plasmas* **20**, 072502 (2013)