Assessing the effect of energetic-particle-driven modes on fusion power gain in burning plasmas

J. Ruiz Ruiz[1], M. Barnes[1], M. R. Hardman[2], A. A. Schekochihin[1], F. I. Parra[3], J. Garcia[4]

[1] Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, UK
[2] CCFE, Culham Science Centre, Abingdon OX14 3DB, UK
[3] Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543, USA
[4] CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France

e-mail (speaker): juan.ruiz@physics.ox.ac.uk

Energetic particles will be ubiquitous in next-generation burning plasmas, most prominently in the form of 3.5 MeV alpha particles issued from the DT reaction. Understanding how they will impact the overall plasma confinement is therefore of dire importance for predicting fusion performance. For decades we have learned that energetic particles (EP) can linearly destabilize certain types of Alfvén modes, which drive large transport of the energetic particles. More recently, theory and numerical simulations have suggested that Alfvén modes could have a beneficial effect on the thermal plasma by generating a stationary zonal perturbation, which could tear apart the turbulent eddies and result in improved confinement. What will be the overall effect of the EP-driven Alfvén modes on the fusion power gain? We address this open question in this work. We solve the power balance equations for the thermal plasma and the energetic particles using parametric expressions for the heat fluxes calculated from local, nonlinear gyrokinetic simulations (CGYRO) corresponding to a recently analyzed, ICRH-heated JET plasma [1]. We find that the energetic-particle drive can supress the thermal plasma turbulence via nonlinearly-generated zonal flows by Alfvén modes. Under these conditions, we find that the EP-transport is large. Unexpectedly, we find that the drive of the thermal plasma turbulence (ITG) can also have a nonnegligible effect on the energetic-particle-driven transport. The consequences of these cross-channel interactions between the thermal plasma and the energetic particles on the overall plasma profiles and resulting fusion power gain will be discussed.

References

[1] J. Ruiz Ruiz *et al.*, Phys. Rev. Lett. **134**, 095103