Nonlinear dynamics of zonal flows and geodesic acoustic modes in ITER

Didier GOSSARD[1], Alessandro BIANCALANI[2], Alberto BOTTINO[3], Thomas HAYWARD-SCHNEIDER[3], Philipp LAUBER[3], Alexey MISHCHENKO[4], Martin PUJOL[1], Martin RAMPONT[1], Juvert N. SAMA[5], Laurent VILLARD[6]

[1] École Supérieure d'Ingénieurs Léonard de Vinci, 92916 Paris La Défense, France
[2] Léonard de Vinci Pôle Universitaire, Research Center, 92916 Paris La Défense, France
[3] Max Planck Institute for Plasma Physics, 85748 Garching, Germany
[4] Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany
[5] Institut Jean Lamour UMR 7198, Université de Lorraine-CNRS, Nancy 54011, France
[6] École Polytechnique Fédérale de Lausanne, Swiss Plasma Center, CH-1015 Lausanne, Switzerland
didier.gossard@devinci.fr

Turbulence develops in tokamak plasmas, due to the gradients of the density and temperature profiles. Zonal, i.e. axisymmetric, flows take part in the nonlinear saturation of turbulence. Two kinds of zonal flows exist: zero frequency zonal flows (ZFZF) [1], and finite frequency geodesic acoustic modes (GAM) [2]. GAMs can also be driven by energetic particles (EP) due to inverse Landau damping, taking the name of EP-driven GAMs (EGAM). In this paper, we investigate the dynamics of zonal flows in the absence and in the presence of EPs with the gyrokinetic particle-in-cell code ORB5 [3]. The ITER pre-fusion-power-operation plasma scenario [4] is considered for these numerical simulations. The nonlinear interaction of EPs and EGAMs is investigated. We observe the EP redistribution in phase space, once the EGAM has reached saturation. The corresponding amplitude of EGAMs is estimated for this ITER experimental regime.

References

1. A. Hasegawa, C. G. Maclennan, and Y. Kodama, *Phys. Fluids* **22**, 2122 (1979)
2. N. Winsor et al. *Phys. Fluids* **11**, 2448, (1968)
3. E. Lanti, et al, *Comp. Phys. Commun.* **251**, 107072 (2020)
4. T. Hayward-Schneider, et al. *Nucl. Fusion* **62**, 112007 (2022)