Linear collisionless dynamics of the GAM with kinetic electrons: comparison simulations/theory

V. Grandgirard

X. Garbet, Ch. Ehrlacher, A. Biancalani[1], I. Novikau[1], Y. Asahi[2], G. Dif-Pradalier, P. Donnel, Ph. Ghendrih, G. Latu, Ch. Passeron, Y. Sarazin, D. Zarzoso[3]

CEA, IRFM, 13108 Saint-Paul-lez-Durance Cedex, France

[1] Max-Planck-Institut fur Plasmaphysik, Boltzmann str. 2, 85748 Garching, Germany
[2] National Institutes for Quantum and Radiological Science and Technology, 039-3212, Rokkasho, Aomori, Japan
[3] Aix-Marseille Université, CNRS, PIIM, UMR 7345 Marseille, France

Geodesic Accoustic Modes (GAMs) and Zonal Flows (ZFs) play an important role in the saturation of turbulence in tokamaks. Zonal flows are an essential element to both predict and limit turbulent transport level. In 1998, Rosenbluth and Hinton [1] showed that Zonal Flows are not damped in the absence of collisions and gave an analytical estimation of the residual value for the particular case of single ion species with adiabatic electrons. The kinetic theory of GAMs in toroidal plasma is well documented (see for instance a brief review in [2]). Until very recently there was no available theory to compute the contribution of kinetic electrons to GAM frequency and damping rate, except one proposal for passing electrons [3]. It was numerically found that considering kinetic electrons do not really change the residual flow and collisionless frequency of GAM [4] but the damping rate which is greatly enhanced by trapped kinetic electrons in region of the tokamak where the safety factor is high [5]. Similar results have been also recovered in [6] with GT5D code and in [7] with ORB5 and GENE codes. An effort to provide scaling formulae for GAM frequency and damping rate has been done [8] with ORB5 simulations.

An analytical estimate of the kinetic electrons contribution to GAM damping has been very recently proposed by C. Ehrlacher, X. Garbet and al. in [9]. In this analytical study, based on a variational formulation (close to the one previously used to study EGAMs [10]), it appears that barely trapped/passing electrons enhance GAM damping, while affecting weakly the real part of the GAM pulsation. We propose to compare these analytical results to the numerical ones obtained with the semi-Lagrangian code GYSELA and the PIC code ORB5.

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