Comparison of GAM frequency and dynamics between Tore Supra experiments and a GYSELA simulation

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Geodesic acoustic modes (GAMs) are a high-frequency branch of oscillating zonal flows (ZF) which play a central role in tokamak turbulent transport. They are believed to be one of the players in the self-regulation process of plasma micro-turbulence that contribute to the formation of transport barriers, such as during the L-H transition. Their interplay with turbulence and zonal flows, and their radial structure remain subject of debate in the plasma transport community. Here, GAMs are observed, characterized, studied in detail and compared in experiments and simulation using very similar analysis techniques.

Experimental data comes from L-mode limited shots of a dimensionless collisionnality scan in Tore Supra [1]. Oscillations of the velocity of density fluctuations in a direction perpendicular to both the magnetic field and the radial directions are observed with Doppler backscattering technique at various radii and spatial scales [2].

Simulation has been run with the flux-driven gyrokinetic GYSELA code. It uses the main experimental parameters of the highest collisionnality scenario. It notably features avalanches [3], $E \times B$ staircases [4] and GAMs.

The radial profile of GAM frequency is compared between experimental data, simulation and various theoretical predictions, both fluid and kinetic. It appears that experimental GAM frequency profile follows theoretical fluid prediction, while GAMs in simulation have higher frequencies close to the linear kinetic prediction. Discrepancies with respective predictions are investigated. Possible evidence for the co-existence of local and global GAMs in both cases is noted.

The dynamics and the non-stationarity of GAMs are also characterized using various time-frequency analysis techniques such as MUSIC (Multiple Signal Classification) and HHT (Hilbert-Huang Transform). It is noted that pulses of GAM trains appear in simulation and experiments with similar properties.

References

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