Multi-field Characteristics and Eigenmode Spatial Structure of Geodesic Acoustic Modes in DIII-D L-Mode Plasmas

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Abstract. The geodesic acoustic mode (GAM), a coherent form of the zonal flow, plays a critical role in turbulence regulation and cross-magnetic-field transport. In the DIII-D tokamak, unique information on multi-field characteristics and radial structure of eigenmode GAMs has been measured. Two simultaneous and distinct, simultaneous, radially overlapping eigenmode GAMs (i.e., constant frequency vs. radius) have been observed in the poloidal $E \times B$ flow in L-mode plasmas. As the plasma transitions from an L-mode to an Ohmic regime, one of these eigenmode GAMs becomes a continuum GAM (frequency responds to local parameters) while the second decays below the noise level. The eigenmode GAMs occupy a radial range of ρ=0.6–0.8 and 0.75–0.95, respectively. In addition, oscillations at the GAM frequency are observed for the first time in multiple plasma parameters, including n_e, T_e, and B_θ. The magnitude of $\tilde{T}_e / T_e$ at the GAM frequency (the magnitude is similar to that of $\tilde{n}_e / n_e$) and measured n_e–T_e cross-phase (~140° at the GAM frequency) together indicate that the GAM pressure perturbation is not determined solely by $\tilde{n}_e$. The magnetic GAM behavior, a feature only rarely reported, is significantly stronger (x18) on the high-field side of the tokamak, suggesting an anti-ballooning nature. Finally, the GAM is also observed to directly modify intermediate-wavenumber $\tilde{n}_e$ levels ($k\rho_s$~1.1). The simultaneous temperature, density, flow fluctuations, density-temperature cross-phase, and magnetic behavior present a new perspective on the underlying physics of the GAM.

PACS: 52.35.Bj, 52.35.Ra, 52.55.Fa

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