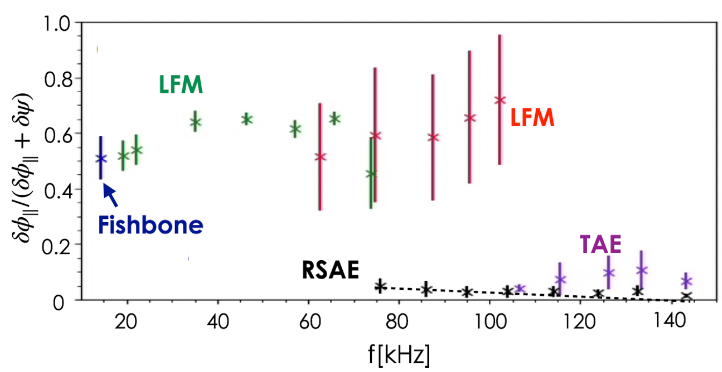
First Measurement of Drift-Alfvén Wave Polarization in Fusion Plasmas[1]

W.W. Heidbrink[1], Xiaodi Du[2], Liu Chen[1,3,4], M.A. Van Zeeland[2], M.E. Austin[5], Jie Chen[6], Yueqiang Liu[2], G.R. McKee[7], Zheng Yan[7]

[1]University of California, Irvine, USA; [2]General Atomics, USA; [3]National Central University, Republic of China; [4]ENEA, Frascati,Italy [5]University of Texas-Austin, USA; [6]University of California, Los Angeles, USA; [7]University of Wisconsin-Madison, USA

Drift-Alfvén waves play crucial roles in both space and fusion plasmas, influencing turbulence, magnetic reconnection, and heat and particle transport. In theory, these waves exhibit a mixture of electrostatic and electromagnetic perturbations, their 'polarization'. Previously, owing to a lack of measurements of the polarization, these waves were not unambiguously identified in fusion experiments but the first measurements of drift-Alfvén wave polarization in a hot, magnetically-confined plasma were recently reported [1]. The breakthrough is enabled by a novel methodology developed from gyrokinetic theory, utilizing fluctuations of electron temperature and density, quantities that are readily measured. The method is general and applicable to all waves with frequencies smaller than the compressional Alfvén and ion cyclotron frequencies and the transit frequency of thermal electrons. Analysis of data from the DIII-D tokamak reveals that waves with frequencies above the geodesic acoustic mode (GAM) frequency such as toroidal and reversed-shear Alfvén eigenmodes exhibit dominant electromagnetic polarization. On the other hand, waves below the GAM frequency, such as fishbones and low-frequency modes [2] show a mixture of electromagnetic and electrostatic polarization, indicating a strong coupling between shear Alfvén waves and drift-acoustic waves. For the first time, drift-Alfvén waves are clearly identified among various instabilities observed in the DIII-D tokamak [1].



Ratio of electrostatic to total potential for several instabilities [1].

[1] X.D. Du et al., Phys. Rev. Lett. **132**, 215101 (2024).
[2] W.W. Heidbrink et al., Nucl. Fusion 61, 016029 (2021).

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