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Theoretical Studies of Low-frequency Alfven Modes in Tokamak Plasmas

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Linear wave properties of the low-frequency Alfven modes (LFAMs) observed in the DIII-D tokamak experiments with reversed magnetic shear [Nucl. Fusion 61, 016029 (2021)] are theoretically studied and delineated based on the general fishbone-like dispersion relation. By adopting the representative experimental equilibrium parameters, it is found that, in the absence of energetic ions, the LFAM is a kinetic ballooning mode instability of reactive-type with a dominant Alfvenic polarization. More specifically, due to diamagnetic and trapped particle effects, the LFAM can be coupled with the beta-induced Alfven-acoustic mode in the low-frequency region (frequency much less than the thermal-ion transit and/or bounce frequency); or with the beta-induced Alfven eigenmode in the high frequency region (frequency higher than or comparable to the thermal-ion transit frequency); resulting in reactive-type instabilities. Moreover, the 'Christmas light'and 'mountain peak'spectral patterns of LFAMs as well as the dependence of instability drive on the electron temperature observed in the experiments can be theoretically interpreted by varying the relevant physical parameters. Conditions when dissipative-type instabilities may set in are also discussed.

Speaker's Affiliation

Southwestern Institute of Physics

Member State or IGO

China, People's Republic of

Primary authors: Dr MA, Ruirui (Southwestern Institute of Physics); CHEN, LIU (ZHEJIANG UNIVERSITY); ZONCA, Fulvio (Associazione EURATOM-ENEA sulla Fusione); Dr LI, Yueyan; QIU, Zhiyong (Zhejiang University)

Presenter: Dr MA, Ruirui (Southwestern Institute of Physics)

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