Study of TAEs excited by energetic electrons in EAST low-density plasmas

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Toroidal Alfvén eigenmodes (TAEs) [1,2] excited by energetic electrons are well demonstrated both in the deuterium plasmas and the helium plasmas in EAST low-density ohmic discharges. Characteristics are studied through a series of experiments to enrich the theory [3].

Letting the line-averaged density ramp down from about 2 to 0.3×10^{19} m^{-3} during the flattop of ohmic plasma, and a suprathermal electron tail is driven, which excites a high frequency (150-250 kHz) instability, detected by both Mirnov coils and reflectometry. The mode frequencies, which correspond very closely to the frequency of toroidal Alfvén eigenmodes, $\omega_{TAE} = v_A/2qR$, are consistent with a precession drift resonance condition with perpendicular energetic electron energies in the range of 200-260 keV, in agreement with hard x-ray profile measurements and analytic and numerical calculations of the energetic electron distribution. Alfvén spectrum of the toroidal mode number (n=1) calculated by GTAW code further confirm the conclusion that the high frequency instability is energetic electron driven TAEs.

Threshold for exciting the TAEs is strongly related to populations of energetic electrons and the plasma parameter range are obtained through a series of experimental explorations. In addition, the damping rates of the TAEs are found to be very sensitive to the energy distribution due to the change of density. Usually, as the density continues to decrease, the TAEs disappear due to lack of the higher-energy electrons. One interesting condition is that the TAE can nonlinearly decay into a geodesic acoustic mode (GAM) and multiple lower kinetic TAEs (LKTAEs) with the same poloidal and toroidal mode numbers of the pump TAE. These results will further deepen the understanding of EPs and lay the foundation for studying the interactions between TAE and other EP driven instabilities [4].

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