Fast Electron Driven Alfvén Eigenmodes in the Current Rise in Alcator C-Mod [†]

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Abstract

Alfvén eigenmodes (AEs) are often observed in both tokamaks and stellarators driven by fast ions from either neutral beam injection or ion cyclotron radio frequency (ICRF) heating. Since the fast particle drive depends on the energy rather than the mass of the fast particles, it is also possible for fast electrons to excite unstable AEs, which have been observed in some tokamaks. By injecting 0.3 – 0.4 MW of Lower Hybrid Current Drive (LHCD) with 90° phasing ($n_{||}$ = 2.3) from the very start of the plasma, a suprathermal electron tail is driven that excites a series of bursting high frequency (200 – 700 kHz) instabilities in the current rise in Alcator C-Mod. These high frequency bursting modes have amplitudes ($\tilde{B}_\theta \leq 3 \times 10^{-6}$ T) measured with poloidal field pick-up coils on outboard limiters, which are in the range observed for Alfvén eigenmodes excited with ICRF heating. These modes are observed very early in the current rise with several bands of frequencies that increase with decreasing density. The frequency at each burst corresponds very closely to the center of the gap frequency for toroidal Alfvén eigenmodes (TAEs), $\omega_{TAE} = \mathrm{v}_A / 2qR$, for integer and half integer q values from 11 down to 5.5. The separation in frequency between the different bands corresponds to n=2, 3, and 4, which is consistent with phase differences between toroidally displaced pick-up coils. Measured average hard x ray photon energies in the range of 25 – 35 keV are in reasonable agreement with the theoretically calculated fast electron energy that matches the precession drift resonance condition for exciting Alfvén eigenmodes.

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