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Energetic-ion Driven Toroidal and Global Alfvén Eigenmodes on HL-2A

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The stationary and nonstationary toroidal Alfvén eigenmodes (TAE) driven by energetic-ion have been observed on HL-2A. The mode frequencies are about 90-200 kHz and toroidal mode numbers for the most unstable mode are n=1–3. The radial structure of the mode with n=2 confirmed by the Alfvén Mode Code (AMC) make up of poloidal harmonic m=2 and m=3, which is a typical feature of TAE. The amplitudes measured by the Mirnov coils suggest that they are much stronger in the LFS than the HFS, which reveals a typical ballooning mode structure. In the down-chirping case, the mode frequency quickly sweeps down from the TAE gap center to the lower frequency gap accumulation point. The internal amplitude can be determined from the frequency sweep speed of TAEs and it will provide input for simulations of potential ion and alpha particle losses due to energetic particle driven modes. The TAEs were found to nonlinearly couple with tearing mode (TM) and result in the appearances of series of Alfvénic modes (AMs). An axisymmetric mode within the ellipticity-induced frequency gap driven by TAEs coupling with TM was found for the first time. The squared bicoherence suggests that two AMs with the same mode number but propagated in different diamagnetic drift directions couple together and lead to the generation of a high frequency mode with n=0. The symmetrical mode with an 'antiballooning'feature prove to be global Alfvén eigenmodes (GAE). It is the even GAE with frequency around 240kHz, which agrees well with experimental observation of 235-240 kHz. The m=1 poloidal harmonic is dominated for the GAE. The experimental results also indicated that nonlinear mode-mode coupling degenerates the confinement of fast ions and it may be one of mechanisms of the energy cascade in energetic-particle turbulence or Alfvén turbulence.

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