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Explosive Alfven Event in HL-2A H-mode Plasmas

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The nonlinear dynamics of shear Alfv{\'e}nic wave fluctuations have become a major concern in magnetically confined fusion, since they can be driven unstable by energetic particles (EPs).
In the present paper, the nonlinear dynamics of toroidal Alfv{\'e}n eigenmodes (TAEs), including nonlinear wave-particle and wave-wave interactions, have been observed in the HL-2A NBI H-mode plasmas. It is found that there are strong nonlinear mode couplings between TAEs with n=3 and low frequency MHD mode (kink or fishbone) with n=1. The pitch-fork phenomena of TAEs can grow explosively and become an explosive instability. The explosive events have two kind fine structures, i.e., multi-modes and pitch-fork. The two kind structures can coexist, but the strong nonlinear mode coupling induces that the pitch-fork weakens or vanishes and the modes blow-up in finite-time, and this indicates that the nonlinear mode coupling may redistribute energetic-ions, destroy hole-clump pairs in the phase-space, and induce three-wave mixing nonlinearly. As a consequence, the TAE nonlinear dynamics can trigger the onset of ELMs and pedestal collapse within several hundred Alfv{\'e}n times. Following the continuous appearances of rich nonlinear dynamics phenomena, more attentions should be paid to understand the underlying mechanisms, as experimental verification of numerical simulations and analytical theory, that are developed for the predictive ability for future burning plasma scenarios.

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