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Chirping in Plasmas; test of criterion for chirping onset and simulation of explosive chirping

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When plasmas have a sufficient number of energetic particles to induce instability, such as may occur in burning plasmas, it is important to have a reliable method of predicting the nature of the unstable state that will arise. Two extreme scenarios for the TAE frequency, ω_{TAE} arises: relatively steady oscillations at one extreme and chirping oscillations at the other extreme. For the first case, this work uses the generalized form of a criterion found by M.K.Lilley, et. al. [Phys.Rev.Lett., 102, 195003 (2009)] that indicates, whether marginally unstable Alfvenic modes destabilized by energetic particles are more likely to chirp or more likely to remain as steady oscillations. This criterion has been applied to data in NSTX and DIII-D to successfully predict the parameters that produce either chirping or steady Alfvenic oscillations. Chirping arises in DIII-D when background turbulence markedly decreases. In the second part of the paper we consider the case where the strength of the driving source of energetic particles increases. Then instability may emerge from the continuum to form what has been called energetic particle modes (EPM). Here we describe a new way of numerically simulating an EPM which enables a significantly increased time-step for the numerical simulations. This study simulates, we believe for the first time, a chirping avalanche that is triggered by an EPM excitation and explains the dynamics with a new analytic theory.

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Primary author: Prof. BERK, Herbert (University of Texas at Austin)

Co-authors: Dr TOBIAS, B. J. (Princeton Plasma Physics Laboratory); Prof. BREIZMAN, Boris (The University of Texas at Austin); Dr PACE, D.C. (General Atomics); Dr WANG, Ge (University of Texas at Austin); Dr KRAMER, Gerritt (Princeton Plasma Physics Laboratory); Dr CHENG, Linjin (University of Texas at Austin); Dr PODESTA, Mario (Princeton Plasma Physics Laboratory); Dr VAN ZEELAND, Michael (General Atomics); Dr NAZIKIAN, Raffi (Princeton Plasma Physics Laboratory); Mr DUARTE, Vinicius (Princeton Plasma Physics Laboratory); Prof. HEIDBRINK, William (Univeristy of California at Irvine)

Presenter: Prof. BREIZMAN, Boris (The University of Texas at Austin)

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