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Magnetic Reconnection during Fast Ion Driven Alfvénic Activity

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Recent simulations of so-called Abrupt Large-amplitude Events (ALE) driven by beam ions in JT-60U show evidence of transient changes in the magnetic topology on the sub-millisecond time scale, giving rise to moderately sized magnetic islands [1]. Since the configuration at hand is magnetohydrodynamically (MHD) stable with respect to reconnecting instabilities in the range of toroidal mode numbers considered ($n = 1, 2, 3$), a significant amount of mode conversion must have taken place via parity mixing. Although this is physically possible within the framework of nonlinear resistive MHD [2], the result is nevertheless surprising since the effectiveness of parity mixing at the relatively high frequencies (40-60 kHz) of the shear Alfvén waves seen during ALEs is not immediately evident. If the numerical prediction can be verified and validated, driven magnetic reconnection may explain the enhanced electron transport seen during ALEs in JT-60U [3]. Moreover, this finding may have significant impact beyond fusion plasmas, for instance in the context of so-called flux transfer events (FTE) in the Earth's magnetopause [4, 5].

Here we report results of a sensitivity study, which is one step towards our goal to clarify the reconnection process that occurs in our ALE simulations. Using the hybrid code MEGA [6, 7], which simulates the self-consistent interaction between beam ions (modeled kinetically) and MHD fluctuations, we test how the numerical parameters affect the evolution of MHD fluctuations with $n = 1, 2, 3$ during one of the events reported in [1]. It is confirmed that the overall ALE dynamics and magnetic island sizes are similar when the spatial resolution and the number of quasi-particles is increased. Randomizing the initial quasi-particle positions along the toroidal angle φ (i.e., changing the discretization noise) is found to have a noticeable influence on the timing of the ALE, akin to the proverbial "flap of a butterfly's wing causing a tornado". Variations between ALEs in different simulations provide new insight concerning multi-mode interactions [1].

The next step is to study the role of dissipation. The default values of the resistivity, viscosity and thermal diffusivity are $\eta/\mu_0 = \nu = \chi = 10^{-6} v_{A0} R_0$, with Alfvén velocity v_{A0} and major radius R_0. Simulations are underway to simulate an ALE with weaker dissipation ($3 \times 10^{-7} v_{A0} R_0$). Our first results on this front indicate that weaker dissipation reduces the threshold in the fast ion pressure gradient at which an ALE can be triggered.

References:
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