PIC Simulation of thermal distribution driven non-Maxwellian by neutral-beam injection in a high beta plasma

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Intense beam driven FRCs are the central focus of TAE's C-2U program [1]. It had been known that beam injection can stabilize some macro-instabilities such as the tilt mode and drift instabilities [2, 3]. In addition, in C-2U we now observe that intense beam drive (i) can excite robust kinetic micro-instabilities, (ii) causes no global plasma destruction, and (iii) can enhance the D-D fusion reactivity. These observations led to a new hypothesis beyond the large orbit paradigm: the robustness of waves with a high phase velocity and its consequences. This hypothesis shares the same philosophy as wakefield excitations [4]. To study the experimental behavior theoretically, we simulate beam-driven micro-instabilities that are non-destructive, but transfer energy from fast ions to the plasma, causing phase space bunching. Such a mechanism may explain an experimentally observed anomalous neutron signal (10–100× the predicted thermonuclear fusion yield), as other explanations have been eliminated (D in the beams, fast-thermal ion head-on collisions, and misinterpretation of T_i). We propose that the injected intense hydrogen beams generate an energetic ion population that then drives collective modes in the plasma, giving rise to an instability and increased fusion rate. A 1D3V PIC code [5] is used to simulate beam-plasma interactions and a two-body correlation function is employed to determine the computational D-D reactivity enhancement. Modifying the experimentally injected beam distribution supports this theory.

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